SAE Journal

AUGUST 1952

PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

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The Standard of Comparison

The application of solid chrome to piston rings, as perfected by Perfect Circle, more than doubles the life of pistons, cylinders and rings. Performance data will be furnished on request. Write Perfect Circle Corporation, Hagerstown, Indiana. The Perfect Circle Co., Ltd., Toronto, Ontario, Canada.

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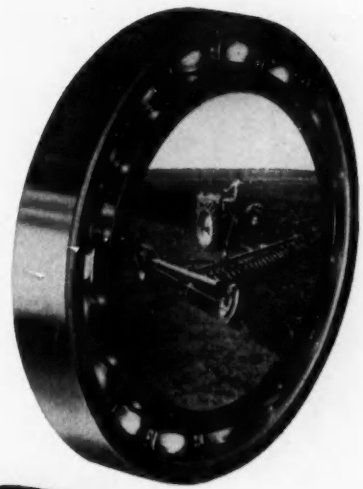

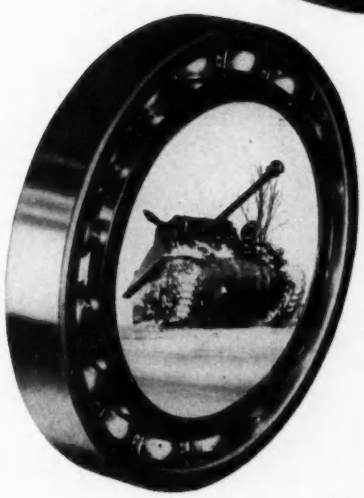

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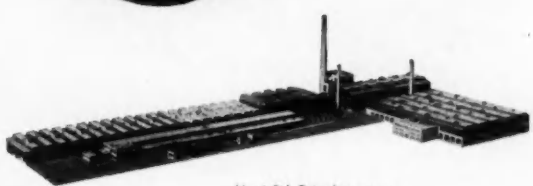

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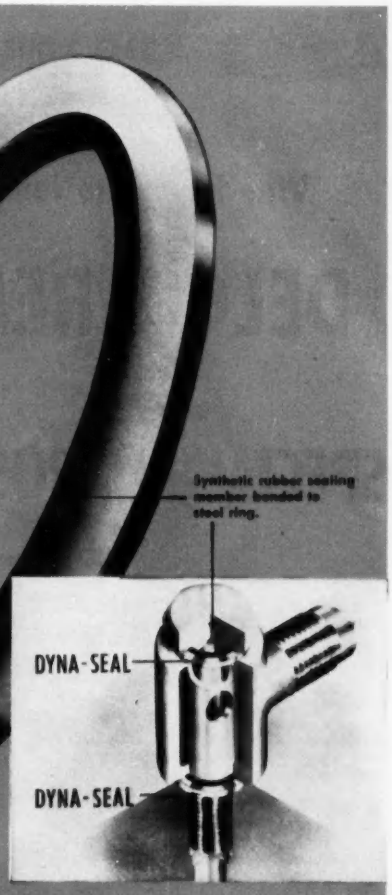

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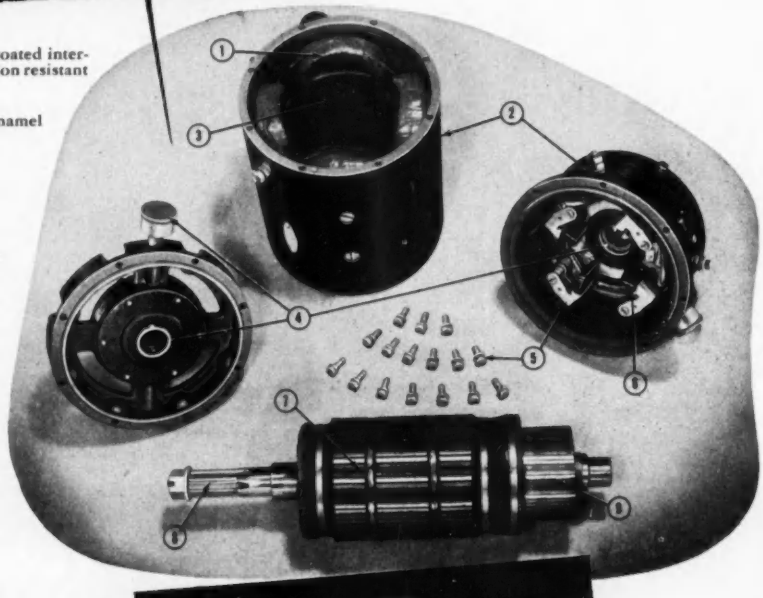

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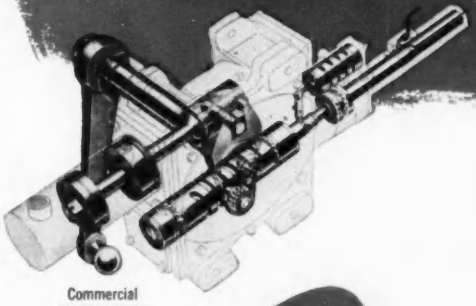

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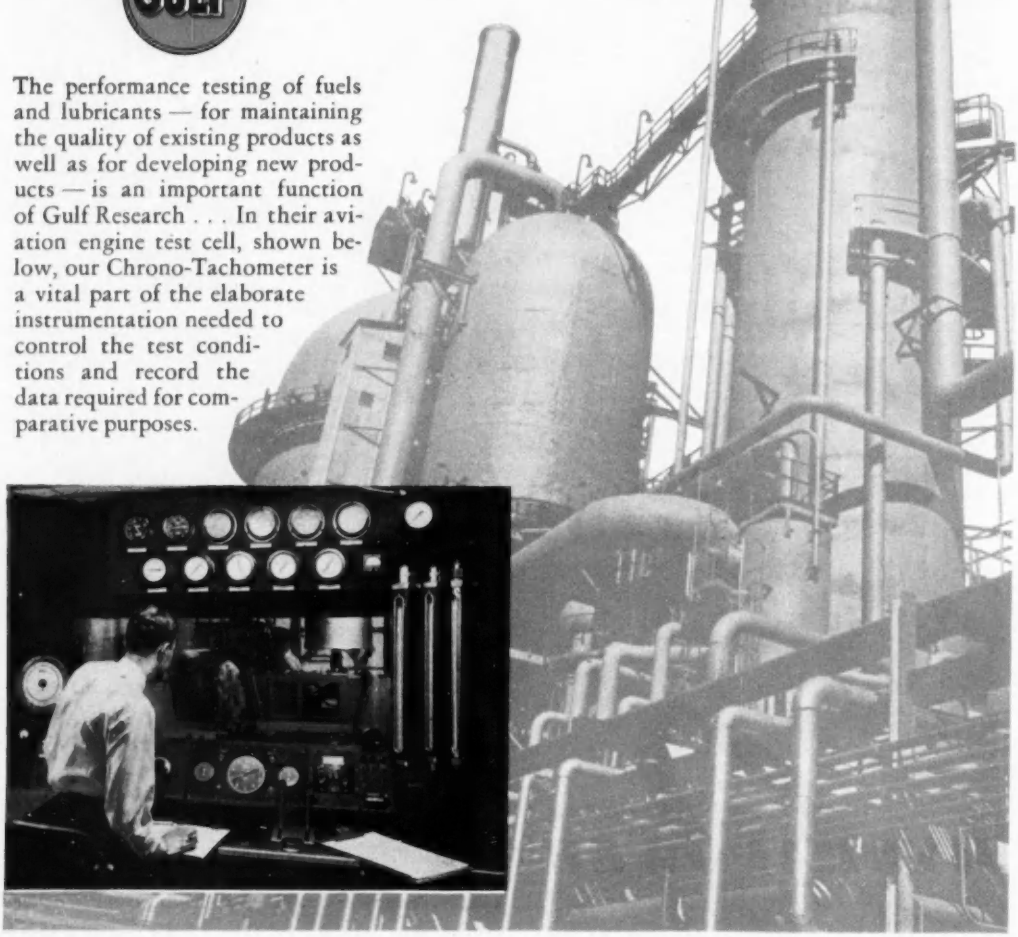

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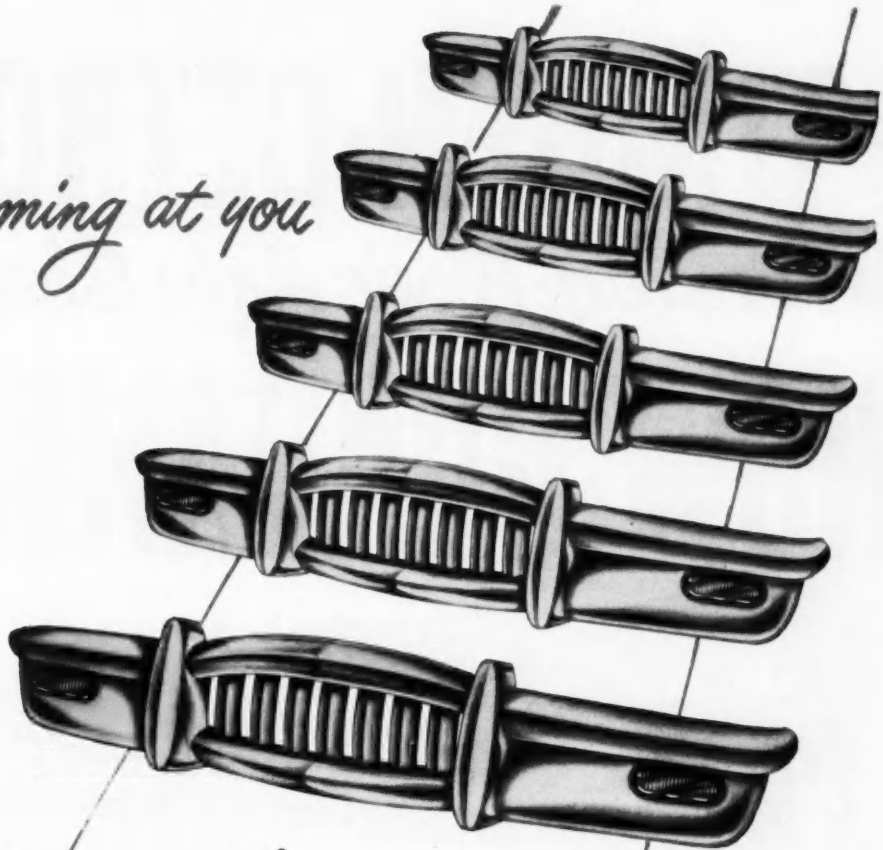

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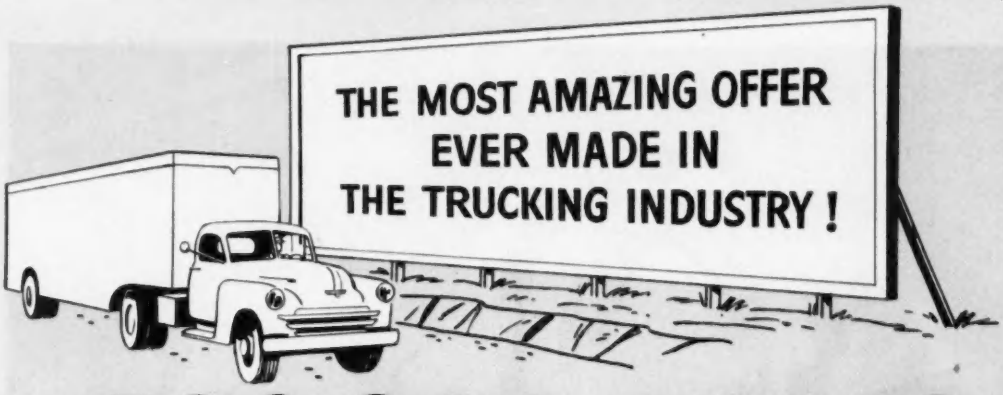

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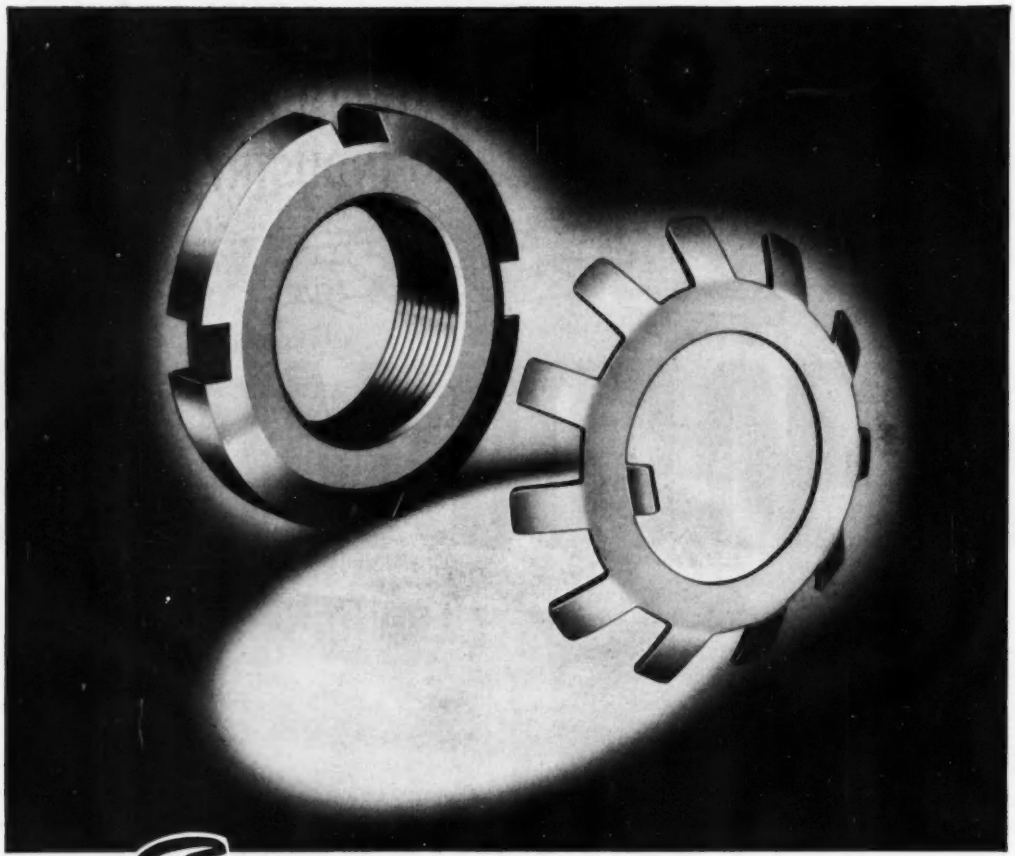

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BUSINESS IN MOTION

To our Colleagues in American Business . . .

For several years this space has been used to tell how Revere has collaborated with its customers, to mutual benefit. Now we want to talk about the way our customers can help us, again to mutual benefit. The subject is scrap. This is so important that a goodly number of Revere men, salesmen and others, have been assigned to urge customers to ship back to our mills the scrap generated from our mill products, such as sheet and strip, rod and bar, tube, plate, and so on. Probably few people realize it, but the copper and brass industry obtains about 30% of its metal requirements from scrap. In these days when copper is in such short supply, the importance of adequate supplies of scrap is greater than ever. We need scrap, our industry needs scrap, our country needs it promptly.

Scrap comes from many different sources, and in varying amounts. A company making screw-machine products may find that the finished parts weigh only about 50% as much as the original bar or rod. The turnings are valuable, and should be sold back to the mill. Firms who stamp parts out of strip have been materially helped in many cases by the Revere Technical Advisory Service, which delights in working out specifications as to dimensions in order to minimize the weight of trimmings; nevertheless, such manufacturing operations inevitably produce scrap. Revere needs it. Only by obtaining scrap can Revere, along with the other companies in the copper and brass business, do the utmost possible in filling orders. You see, scrap helps us help you.

In seeking copper and brass scrap we cannot appeal to the general public, nor, for that matter, to the small businesses, important though they are, which have only a few hundred pounds or so to dispose of at a time. Scrap in small amounts is taken by dealers, who perform a valuable service in collecting and sorting it, and making it available in large quantities to the mills. Revere, which ships large tonnages of mill products to important manufacturers, seeks from them in return the scrap that is generated, which runs into big figures of segregated or classified scrap, ready to be melted down and processed so that more tons of finished mill products can be provided.

So Revere, in your own interest, urges you to give some extra thought to the matter of scrap. The more you can help us in this respect, the more we can help you. When a Revere salesman calls and inquires about scrap, may we ask you to give him your cooperation? In fact, we would like to say that it would be in your own interest to give special thought at this time to all kinds of scrap. No matter what materials you buy, the chances are that some portions of them, whether trimmings or rejects, do not find their way into your finished products. Let's all see that everything that can be re-used or re-processed is turned back quickly into the appropriate channels and thus returned to our national sources of supply, for the protection of us all.

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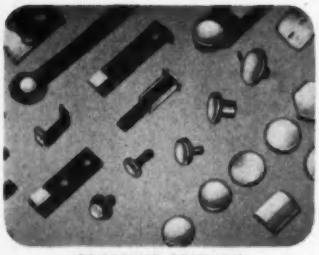
General Plate manufactures all grades of silver solder, solder filled wire, solder clad base metal, etc., with various melting ranges for all applications. General Plate Engineers will gladly help you with your problems.



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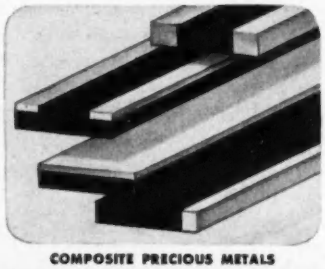

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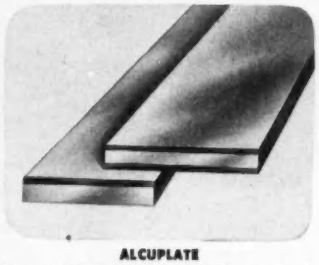

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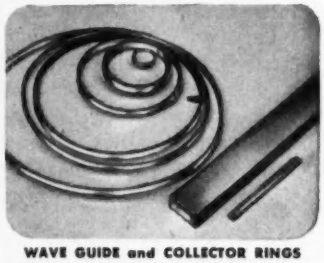

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For the Sake of Argument

Ruts—Their Dangers and Uses . . .

By Norman G. Shidle

Each one at lunch that day agreed that getting in a rut is easy and undesirable. (They were all against sin, too.) Alone and collectively, they cited and frowned on the rutting tendencies of absent associates.

"Those test reports Sam sends every month" were criticized as being everlastingly the same . . . "only the figures are different . . . never any interpretation of what they mean." Absentee Bill got panned for having tunnel vision about out-of-routine ideas needing sudden execution by his department. . . . And so it went.

Finally one member of the group cut in with: "I wonder how we are doing ourselves? Right off quick, I can't think of a good answer to the question: 'What rut have *I* gotten out of today?' "

That slowed the conversation up some, but it finally moved on again—into greener fields.

The fellow who runs a good operation, someone said, faces more rut-danger than anybody else. He is likely to be satisfied with good results. "The good is often enemy of the best," somebody quoted.

Then one of the more erudite lunchers recalled that Rabindranath Tagore once urged the need to recognize that "the possibilities of perfection always outweigh the probability of imperfection." That means "Don't be afraid to take a chance," someone interpreted.

After the crowd broke up, our thoughts ran on. The real trick is to keep seeing over the sides of our rut, while still running in it. Good habits are ruts . . . necessary to maintain momentum for our everyday requirements. Being in a good rut makes it easier to look around and keep moving ahead at the same time. Then we can jump out and start a new rut—and maybe join it with the old one at a later junction.

The real trouble lies with our own vision and attitude —not essentially with our rut-position at any given time. Looking down at our feet, we'll just dig our rut deeper. Looking up and around, the rut keeps us on the track until we see a good place to go. But only by looking up and around will we ever be lured by new scenery to get out of the rut we're in.

What rut have *you* gotten out of today?

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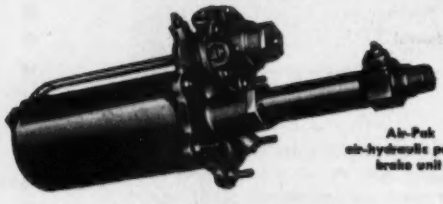
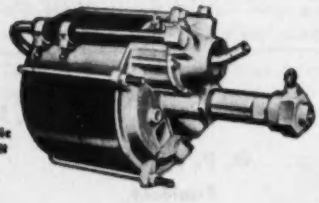


Air-Pak air-hydraulic power brake unit



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Petroleum Products:

. . . . There'll be enough IF we expand all facilities in proportion.

C. E. Davis, Assistant Deputy Administrator Domestic Petroleum Operations, Petroleum Administration for Defense

Excerpts from paper "Future Outlook for Petroleum Products," presented at SAE Summer Meeting, Atlantic City, June 5, 1952.

THE picture now is one of generally adequate supplies of petroleum products throughout the world. But there is virtually no cushion of reserve capacity to take care of any new emergencies. There are a couple of trouble spots—aviation gasoline supply is still not satisfactory and residual fuel is in short supply—but other than this the supply situation now appears to be in hand.

Since June 1950, two heavy waves have rocked the boat. The first wave was the war in Korea. This, of course, brought increased demands from the military for petroleum products. In addition, however, it set off a great increase in rearmament and general industrial activity, both in this country and abroad, on top of the rise of industrial activity already going on. The result was that civilian demands for petroleum products rose faster than their normal rate of growth.

The direct effect of the Korean War—in increased military demand—produced only a very small part of the wave. Military demands now are taking only about 5% of our supply of petroleum products at the present time. Direct military consumption of petroleum products has not been a problem since Korea.

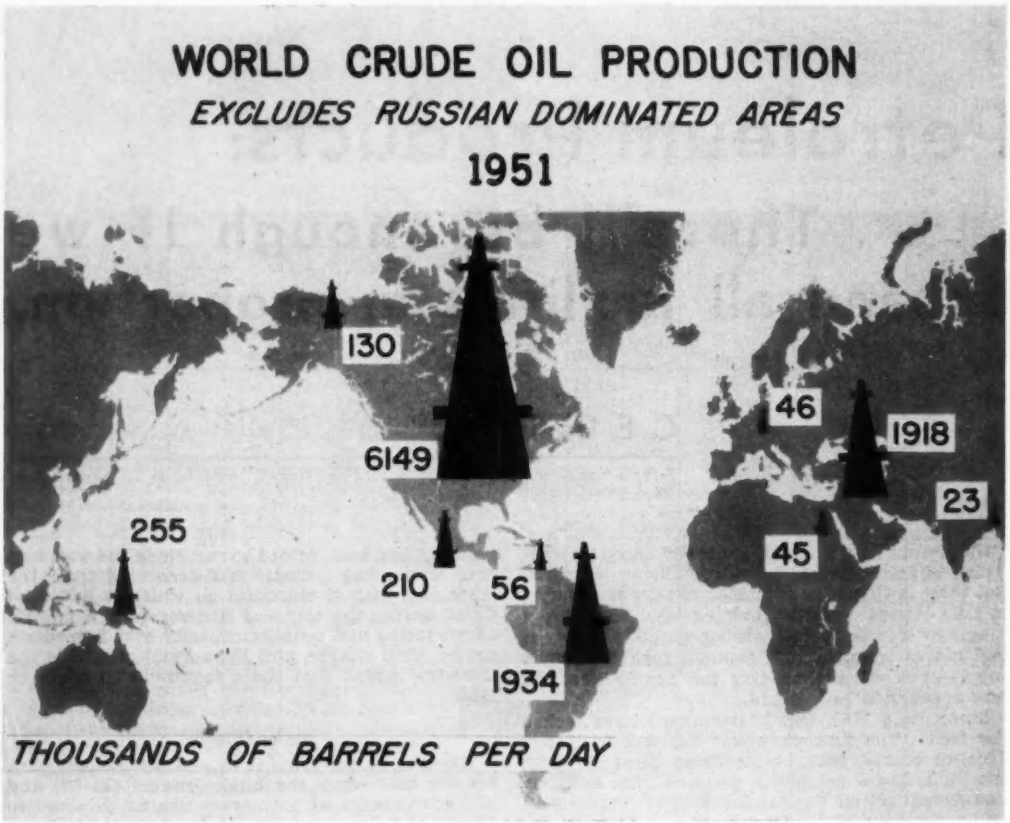
However, aviation gasoline is scarce. This may seem strange, in view of the fact that World War II capacity to produce 100-octane aviation gasoline approached 600,000 bbl a day, while our present demand is considerably less than half as much. A part of the answer lies in the fact that many of the plants producing ingredients for aviation gasoline were uneconomic in peacetime, and their owners had shut them down or converted them to other uses by June 1950. The rest of the answer lies in the higher octane requirements of present-day fuels which, in effect, reduces our capacity greatly.

Fortunately, the oil industry had the excess capacity to handle the greatly increased demand for products resulting from the Korean War and the mobilization effort at home. By 1949, the neck and neck race between supply and demand, which the industry had been forced to run since the war, had been won. The industry had recovered from the starvation diet of materials on which it had subsisted during the war and had regained a margin of producing and refining capacity over immediate needs. This reserve, plus the normal growth of the industry, meant that those requirements could be met.

Iranian Dispute

However, in the summer of 1951, the second wave hit the boat when the Anglo-Iranian Oil Co. and the government of Iran were unable to come to terms, and the output of crude oil and petroleum products in Iran ceased. This immediately deprived the free world of over 700,000 bbl a day of crude oil production, from a part of which over 500,000 bbl a day of refined products had previously been produced by the largest refinery in the world at Abadan. The effect of this was felt immediately in the Eastern Hemisphere—in the areas normally supplied by Abadan. Some of those areas started running out of supplies almost at once. It was apparent, then, that if the defense efforts of our allies in the Eastern Hemisphere were not to run out of gas, it would be necessary to do a face-lifting job on the supply lines of the entire world. This was done. Crude oil production was stepped up in other mid-Eastern countries, in the United States, and in other areas, and refining capacity was run at virtually full throttle in all parts of the world. Roughly, one-third of the loss from Abadan was made up by increasing United States exports; two-thirds were made up by increased output elsewhere in the world.

In order to restore reserve productive capacity to a reasonable level, the petroleum industry is engaged in the largest general expansion program in its history. There is one very large "IF"—*if*, steel, copper and aluminum and other materials are made available, we should do better than hold our own



The vertical height of the derricks is proportional to the volume of crude oil production in each major area of the world in 1951. United States production is over six million barrels a day; world production, excluding Russian-dominated areas is about 11 million barrels a day.

The rise of Mid-East production in the last decade has been tremendous. It has been estimated that the reserves in that area now exceed the reserves in all of the rest of the world combined. The lush Mid-East wells produce an average of about 8500 bbl per day compared with the average of 12 bbl per day per well in the United States. But the engineering and logistical problems and costs of moving crude to market are frequently very great.

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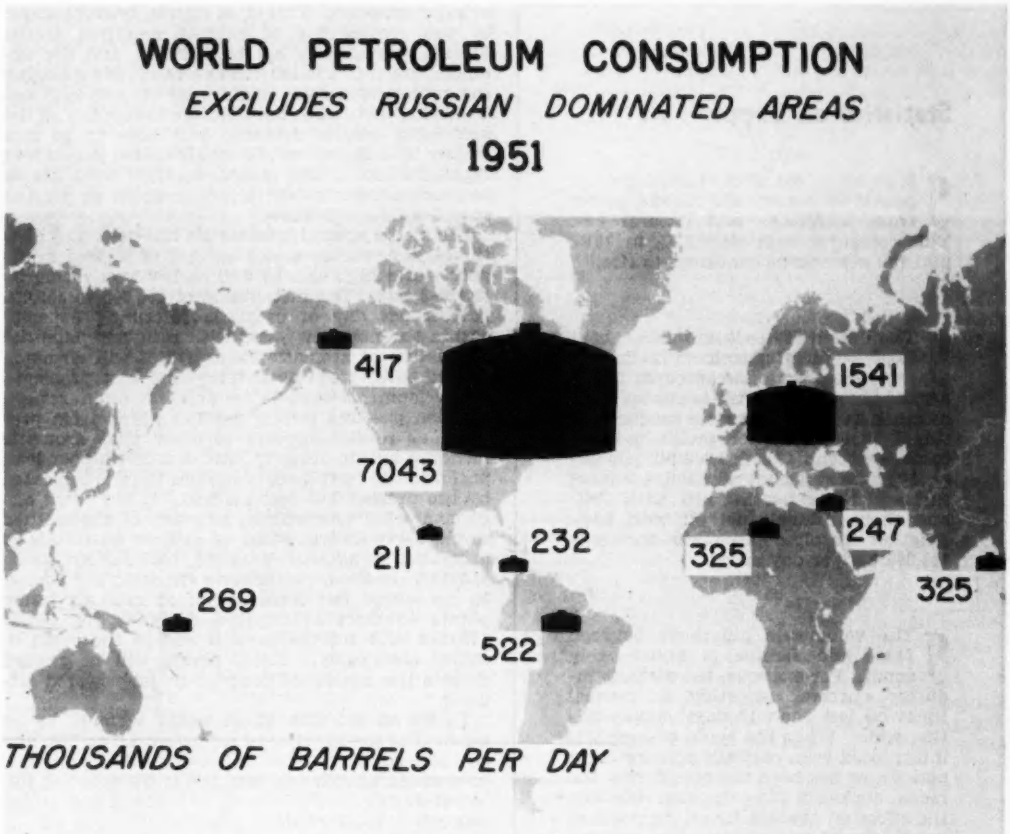
during the next two years. We pay for our oil with steel coins. Quite literally, we trade steel for oil and we trade a great deal of it. Roughly 10,000,000 tons a year, or about 11% of the nation's output of finished steel goes into the oil and gas business.

Moreover, this is not a part of the economy that can stand starvation. Every day old oil wells die, and new wells, which are generally deeper and use more steel, must be drilled to replace them. We must run fast just to stay even. If drilling were stopped for just one year, crude oil production potentials would decline 8 to 10%. But we cannot just stand still; we must grow.

It should be stressed as strongly as possible that this is the only way to really prepare the petroleum industry for war—by overall expansion. The idea that we can solve our wartime supply problems by storing up products in tanks somewhere, or storing crude oil underground, is a fallacy. Petroleum products are too bulky to store in any substantial amount, and keeping the crude oil underground in special military reserves has two objections. First of all, it takes a matter of years to drill the wells to get the oil out. And second, assuming that the wells are drilled beforehand, it takes more pipelines to get the oil to the refinery, more refinery capacity to make the oil into products, and more trucks and tankers to get the products to their destinations. *Balanced* expansion, integrated expansion of all facilities together, such as the oil industry nor-



A striking characteristic of the oil industry is its rate of growth. Demand for petroleum products in the United States has grown by 8% a year since the war, and in Europe by 14%. Before the war, the rate of growth was only about half as rapid, but it was steady year after year.

The tanks are drawn proportionate to 1951 demand in each area. The United States, of course, is by all odds the biggest user of petroleum products. With 7½% of the world's population, we now use two-thirds of the world's petroleum products. Our use is 2 gal per person per day. Use in the Far East is only about 2 tablespoons per person per day.

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mally undertakes for its own economic reasons, is the only satisfactory answer.

Many people feel that some of the most promising territory in which to hunt for new petroleum supplies lies in what is called "the tidelands". The tidelands in question are the areas covered by a relatively shallow depth of water that may extend for miles beyond the shore in the coastal regions, such as California and along the Gulf Coast. These underwater lands were formed by the same forces and in the same eras of geologic time as the neighboring land above water, and preliminary exploration has uncovered in these underwater areas many of the same types of structure that have produced oil on land. Oil, in fact, has been discovered in a large number of so-called tidelands areas already.

Further development, however, has almost entirely stopped as a result of controversy between the federal government and the tidelands States concerning sovereignty over these areas. Development of these offshore areas is immensly costly and hazardous to the operators, and it is not likely that they will go ahead with further development until the issue is settled.

Aviation Gasoline

While the general design of reciprocationg engines for aircraft has been pretty well frozen for some time, there has been and will continue to be a gradual increase in average quality requirements for

Statistics on Supply . . .

¶ More than half of our total supply of power, stationary and mobile, comes from petroleum and natural gas. This compares with only 12% in 1915, and the percentage continues to rise.

¶ The United States is now using about 7,000,000 bbl of petroleum products a day. Motor gasoline accounts for 2,842,000 bbl or 40%. This is almost twice as much as the next largest product, residual fuel oil. After motor gasoline comes kerosene with 339,000 bbl per day or 5%. Next comes distillates (diesel fuel and home heating oil) with 18%, and then residual fuel oil with 22%. Aviation gasoline accounts for only 145,000 bbl per day or 2%.

¶ The volumetric difference between feast and famine is unbelievably small. For example, the aircraft industry operates smoothly in normal times on less than 10 days' supply nation-wide. When the chain of supply is interrupted even partially and for short periods, as has been the case during the recent strikes in the petroleum industry, the effect on availability at the point of use is almost immediate. The position with respect to other products is more favorable although the same principles are followed in the chain from well to consumer. The intermediate storage from source to end use is largely maintained for operational purposes, and a substantial volume of the total stocks above ground is represented by stocks in transit. Every barrel of motor gasoline in storage in the United States would supply the requirements for only about 45 days, and most other products are not as well supported by inventories.

¶ Development of a substantial new oil field will take something on the order of five years. It seems impossible to escape the conclusion that only oil fields in being can be relied on to fuel this nation in time of war.

aviation gasoline. This is, of course, brought about by the greater use of engines requiring Grade 115/145, particularly by the Military, and the extended use of Grade 108/135 as a result of increasing the ratings of certain engines which normally use Grade 100/130. Both the shortage in supply and the increasing quality demands will have to be met largely by installation of new alkylation plants and rehabilitation of idle plants, together with use of as much aromatic-type blending agent as present specifications will allow.

Use of the aromatic materials has been and continues to be rather minor because of limited availability and high cost as well as low lean rating by the F-3 test. The installation of 200,000 to 300,000 barrels per day of catalytic reforming capacity within the next few years with resulting potential production of aromatic concentrates will do much toward solving the availability and cost problems.

Development work is in progress on a revised aviation gasoline testing method which from preliminary results appears to show that aromatic blending agents actually have a much higher lean performance in full-scale engines than is indicated by the present F-3 test method. If the work can be completed successfully, adoption of the method would allow incorporation of greater quantities of aromatics in aviation gasoline, particularly Grade 115/145. In the meantime, we are doing our utmost to encourage the construction of new alkylation plants to meet anticipated demands for Grade 115/145 both for the present and in the event of major emergency. These plants will be needed despite the continued progress in jet-powered aircraft.

In an all-out war, there would seem to be no doubt that the practice of supplying 4.6 cc TEL and military volatility aviation gasoline to commercial uses would be followed, which was the practice followed during World War II. If no such war occurs and when total aviation gasoline demands can be met, the PAD Order requiring a minimum of 4 cc of TEL in commercial aviation gasoline will be dropped, but whether or not airline operators will at that time revert to 3 cc gasoline will also depend upon economic as well as other factors.

Motor Gasoline

At the present time motor gasoline octane numbers are at approximately the same level as they were a little over a year ago when PAD Order No. 1 limiting lead usage was imposed. The weighted average octane number for premium grade was 91.1 in April this year and 90.7 in April last year. Regular grade was unchanged at 84.1. There is one important difference in the situation, however. The average TEL content is 11% less than it was a year or so ago, 1.70 cc per gal now, against 1.91 cc then. This reflects the installation of catalytic cracking capacity and of catalytic reforming and polymerization capacity during the last year, as well as other manufacturing changes made to improve octane number without the use of TEL.

We estimate that by the end of 1953 catalytic cracking capacity will have increased to about 3,000,000 bbl per day, a 50% increase over the level of January 1951. Of the order of 250,000 bbl of catalytic reforming will be in operation by the end

of 1953. These latter units alone would allow an average increase in total motor gasoline quality of nearly 2.0 octane numbers.

Construction of both cat crackers and cat reformers will continue beyond 1953, as demands for both quality and quantity of gasoline increase. One major refiner indicated at the recent API meeting in San Francisco that his studies showed that the octane number of premium gasoline would rise from the present 91 to 96 by 1955, and that the regular grade would increase from 84 to 88. One also obtains approximately these same numbers by extrapolating the octane number increase over past years, correcting for abnormal periods such as World War II and the lead-limitation period.

This is all predicated on an extended mobilization or "guns and butter" situation. In the event of an all-out war, motor gasoline supplies would, of course, be rationed severely and octane numbers of civilian gasoline frozen at whatever level necessary to allow reasonably satisfactory operation of most passenger cars and trucks on the road at that time. This might mean a reduction in octane number and might also require spark adjustment on some cars, but overall petroleum supplies are expected to be very critical during the initial period of an all-out war, and steps would have to be taken to discourage or prevent the use of certain octane-improving processes which reduce total liquid volume.

The overall consumption of normal gasoline components for aviation fuels, including butylenes and butane used in alkylation, is not expected to result in any large effect on motor gasoline volatility. Overall, therefore, gasoline of usable octane number and volatility will be available but in only limited quantities.

With respect to tetraethyl lead for motor gasoline, we do not expect any further problems in connection with normal supplies. PAD Order No. 1 was imposed at a time when no spare productive capacity was available to permit accumulation of a strategic reserve. Thanks to the cooperation of the TEL manufacturers and in spite of a temporary shortage of metallic lead last fall, the first phase of that reserve has been accomplished and the usage provision of the Order has been lifted.

Usage of lead has not jumped markedly beyond that expected and there has been no evidence, thus far, of an "octane race." We anticipate a slight drain upon accumulated inventories during the peak demand months this summer, which may be largely offset by the added accumulation resulting from the recent strikes, but at no time do we think that the level of reserves will be reduced to a dangerous point. During this year, a substantial amount of new TEL productive capacity will be placed in operation and by the end of the third quarter, capacity should be well in excess of normal demand, and inventories can be held at any desired level.

In the event of all-out war, there will be, as a result of rationing of civilian motor gasoline, enough TEL manufacturing capacity to supply high-octane aviation gasoline, military motor gasoline, and civilian motor gasoline. Because of the possibility of loss of manufacturing capacity or reserve stocks during a war, PAD is studying the advisability and the mechanism of further dispersal of the strategic reserve supply of TEL.

One final comment on motor gasoline is the considerable interest shown in the use of LPG as motor fuel. This development will no doubt find some further application where circumstances are favorable, such as in heavy-duty operations.

Diesel Fuel

In spite of large increases in diesel fuel consumption over the past few years and an expected continuing increase, supplies of diesel fuel are adequate and will continue to be adequate, short of major emergency. While high-speed diesel fuel is generally produced as a separate fuel, many refiners and marketers still handle regular grade diesel and No. 2 fuel oil as a single product through the same facilities. It will become necessary in some instances to manufacture and handle the regular grade diesel as a separate product, particularly where cracking operations become so extensive that the No. 2 fuel oil blended from cracked gas oils has insufficient cetane value.

PAD, shortly after its inception, advised technical representatives of the Association of American Railroads and the Coordinating Research Council that rather pronounced degradation in the quality of civilian diesel fuels would occur as a result of stepped-up demands for jet engine fuel. Based on the latest estimates of wartime product requirements, however, we are now of the opinion that no significant lowering of quality of civilian diesel fuel would occur. It is very likely now that the CRC will not undertake the extensive, full-scale engine test work on lower-quality fuels which had been planned.

In the case of diesel fuel supplies during wartime, we would have very much the same situation as for motor gasoline. That is, there would be an initial shortage of total petroleum product volume. Jet fuel, domestic heating oil, and residual fuels would all compete with diesel fuel for the middle-of-the-barrel fraction. Residuals would be blended with distillates below usual viscosity levels to extend the supply to meet requirements under wartime conditions. Since jet engines can also use gasoline fractions, it would be possible to minimize the requirement of distillates for jet fuel. It might be necessary to use gasoline-powered rather than diesel-powered installations wherever possible. In cases where a choice existed between diesel and residual uses, the use of the more efficient diesel equipment might be necessary, again to conserve total full volume. The remaining distillate would be available for heating and diesel use, and we are reasonably certain that diesel quality would be adequate even though volume might be insufficient. For peacetime operations, we do not believe that increasing use of jet fuel would have any significant effect on future diesel fuel quality.

Considerable interest is currently being shown in amyl nitrate as a cetane improving additive. The Navy has made extensive tests and we understand that the tests show that a fuel brought up to 50 cetane number with amyl nitrate performs substantially the same in Navy diesel equipment as a normal 50 cetane fuel. A major chemical manufacturer is considering the production of amyl nitrate in quantity. While we do not foresee any immediate need for production of 50 cetane diesel with amyl

nitrate, it is possible that in time of emergency this material will have a logistical value even though generally enough 50 cetane fuel should be available. In the meantime, some refiners may find amyl nitrate useful in achieving uniformity in blending to the usual cetane levels.

Synthetic Fuels

On the subject of synthetic fuels, there should be no doubt in your minds that *technically* we can make high-quality liquid fuels synthetically from both coal and oil shale. Whether, or if you prefer, "how soon," we, as a nation, build a synthetic liquid fuels industry depends really on the cost of such an industry, and by cost I mean the cost in money, manpower, and materials. Studies made by the Bureau of Mines and the National Petroleum Council revealed wide difference in both construction and operating costs to produce synthetic fuels from coal. Since the area of disagreement lies well above the reality of present-day prices, it does not seem likely that there will be any rush to build such plants with private capital.

It will cost a great deal in money and materials to build enough synthetic fuels capacity to make any real contribution to our liquid fuels supply. The Bureau of Mines estimates that a 30,000 bbl a day oil-from-coal plant will cost over $400,000,000. At that rate, it would cost about three-quarters of a billion dollars to increase our liquid fuels capacity only 1%. In the light of this, it would seem apparent that no quick or easy solution to our problems of supply lies in that direction of synthetics.

Lubricating Oils

In the lube oil field, PAD has been concerned with both quantity and quality of supplies. A survey conducted about a year ago showed that there was at that time approximately 170,000 bbl per day of lube oil capacity in the United States, made up of 106,000 bbl per day solvent type and the balance conventional. These facilities can be operated at 90% of capacity on a sustained basis so that the effective maximum production is about 95,000 bbl per day of solvent and 65,000 of conventional. Although some new capacity is under construction, very little has been completed.

For this year it is estimated that domestic consumption will average 120,000 bbl per day for total automotive, industrial, and military uses. Another 35,000 bbl per day will be exported. Estimates made a year ago, based on the mobilization program envisioned at that time, provided for an increase in domestic consumption of 25,000 bbl per day in 1955 over that in 1951. However, new lube producing facilities are being built in the United Kingdom, France, and Italy and will supply an increasingly larger proportion of foreign requirements. Total foreign supplies are expected to double by 1955, while imports from the United States will be cut in half. The net result is that under our limited defense expansion program the total volume demand in 1955, both domestic and export, could be met with present capacity. This means that if only total lube oil supply and demand are considered without regard to quality, no new manufacturing facilities need be built before 1955, unless there is a war.

However, quality cannot be ignored. Our solvent refining facilities have been operating virtually at capacity since July 1950, and the trend toward high viscosity index oils is expected to continue. Most of the high quality oils are produced by solvent refining and, while some high VI oils are produced by conventional methods, these plants are limited as to the types of crudes that can be processed and by the availability of crudes in a given locality which will produce naturally high VI oils. Civilian requirements for automotive lubricating oils will be for oils of 85 VI and higher. The greatest percentage of the military requirements is and will be for 85 VI and higher. Therefore, the major portion of the 25,000 bbl per day increase in demand by 1955 must be supplied from new solvent refining facilities. If all-out war requirements are considered, the total demand increases even further in spite of reduced civilian demand resulting from the rationing of motor gasoline.

As a result of these studies, PAD recommended and obtained approval for an expansion program involving start of construction of solvent refining capacity for 15,000 bbl per day of high VI, by the end of 1952, and an additional 13,000 bbl per day by 1955. Installation of this capacity may hasten the obsolescence of 20,000 to 25,000 bbl per day of conventional capacity. Because of this fact, PAD has recommended that new projects for high VI be given accelerated tax amortization to the extent that 65% of the capital cost can be written off over a five-year period with the balance in accordance with normal practice. Permission to construct and allocation of controlled materials are also granted as soon as requested.

According to present estimates, new capacity for only 1610 bbl per day will be completed by December 1952, with another 3500 bbl per day under construction or definitely planned for construction. Several other projects are under consideration, but unless these are firmed up and others planned there will be a shortage of high VI oils by 1955.

It is unfortunate that right at this particular time we appear to be entering one of those periods characteristic of the lube oil business in which a general liquidation of consumer inventories is occurring. Historically, supply and demand fluctuate widely, with demands dropping when supplies are plentiful and increasing when supplies become scarce. Until this liquidation is completed, refiners are reluctant to undertake expansion programs and invest capital from which there is no immediate prospect of return. However, if history repeats, demand by distributors and jobbers will again rise to a peak in one and a half to two years.

Lubricating Oil Additives

In discussing the subject of additives used for the production of high quality lubricating oil, the first point to be determined is the volume of additives desired; the second is the need for such additives; third, the program established to meet these needs; and finally, the progress which has been made in filling the programmed requirements.

Two surveys to determine volume of oil additives required were conducted. The first survey con-

ducted during January 1951 covered the lube oil refiners. The second covered the additive manufacturers and was conducted in April 1951. These surveys indicated that detergents were the only lubricating-oil additives which were in critically short supply. The production of detergent additives in 1950 averaged 4.2 million lb per month. Pre-Korean demand was below that level, but rose very rapidly, reaching 8 million lb per month in the latter part of the year. Facilities capable of producing only 5 million lb per month on a sustained basis were unable to meet this demand. To make the situation worse, the demand for 1952 was estimated to be slightly over 15 million lb per month.

Wear Data with 2-104B Oils

The largest portion of this great increase in demand was for the upgrading of premium oil to the heavy-duty level. The necessity of this extensive upgrading was open to question. Factual information was needed to determine whether this high-detergent production was necessary for defense. Accordingly, extensive fleet operational data were obtained on cars using lubricating oil containing various proportions of detergents. Reports were obtained from 12 companies, including lubricating oil manufacturers, rubber companies, and automobile manufacturers, where millions of miles of actual operating data on all types of services including office-to-home intermittent driving, delivery service, and continuous highway driving had been separately studied.

The results of these tests indicated that those oils of 2-104B specifications or higher would reduce the wear on critical engine parts by not less than 22%; reduce the sludge and lacquer deposit by a similar per cent; increase the time between overhaul jobs; and finally, reduce the consumption of oil by a substantial amount. The saving in oil was an important item. During World War II, the increase in lubricating oil consumption for 1945 over 1941 in passenger cars and trucks was 7000 bbl per day, and was attributable to a large degree to wearing of engine equipment. A major portion of this could be eliminated if high-detergent oils were used.

Other factors which were considered in establishing the essentiality of lubricant detergents were the changes which have been made in motor car design and in the types of fuel available. The use of heavy-duty oil is specified by the manufacturer for a large number of passenger car engines of post-war design. Field usage reportedly has demonstrated that this oil is necessary to lubricate these engines properly.

Automotive fuels have a definite effect on engine cleanliness and performance. In order to provide gasoline of higher octane and in greater volume, it has been necessary to increase the amount and intensity of cracking. These gasolines generally cause dirtier engines. This, however, can be overcome to a large degree by using lubricating oils containing larger amounts of detergents.

After studying extensive data and consulting with the military, it was decided that the savings in parts, car life, manpower, and oil were sufficient to justify the increased use of detergents. In addition, this approach had the advantage of making most of the high quality civilian oils suitable for military use without extensive revision. This is an important consideration, since lubricating oil requirements for the military services increased at a very rapid rate when under all-out emergency conditions. Accurate estimates of these military requirements are difficult to obtain when the equipment in which the oil is being used is being changed in the direction of making engines of higher power output per pound of engine.

The actual program based on this information was to increase detergent production by 10 million lb per month by 1953. This involved producing the organic and metallic components used to manufacture the additive as well as the finished product.

The next question which had to be answered was whether industry would support this extensive program without some assistance. It was found that some companies were willing to undertake the expansion but did not feel that this threefold increase could be utilized in normal times. In fact, very few companies would consider the expansion unless a portion of the unusually high risks were borne by Government. On the basis of these facts, it was decided to support both the basic components and the finished additive facilities with accelerated tax amortization, until the goal of 10 million lb per month active in ingredient was reached.

Basically, a lubricating-oil detergent is composed of an organic compound usually acidic in nature, reacted with a metallic hydroxide. The organic components include but are not limited to petroleum sulfonates, aromatic compounds, and various synthetic polymers. No distinction was made between the various organic raw materials submitted by the chemical companies in applications for necessity certificates, as long as these components had been used in an oil which had received Army Ordnance approval, either in the 2-104B classification or in the new MIL series.

Additive Production

The metallic components include such things as barium, calcium, magnesium, and in some cases zinc. It was found that all but barium were in adequate supply. PAD supported one application to increase the production of barium which adequately provided for this part of detergent manufacture. Going back to the organic portion of the detergent, it is difficult to say that a given number of pounds of organic component is needed to produce 100 pounds of finished detergent. For some combinations, a pound of organic material is needed to make a pound of the finished detergent. In other combinations, only a half pound is needed. For this reason, the ratio of organic components to finished additive was first set at one to one. On the basis of additional experience, however, it now appears that the ratio should be 0.85 to one. In terms of end-product goal, this means that facilities to produce 10 million lb per month of finished additive were needed.

At the present time, proposed projects for plant capacity have been received in PAD amounting to slightly over 10 million lb per month of the finished additive and about 8.5 million lb per month of the organic base materials used for the production of the finished materials. PAD has recommended ac-

celerated tax amortization for these projects, and DPA has favorably acted on facilities to produce 7.6 million pounds of the organic component and 9.9 million lb of the finished additive. Certain of the projects included in the program may drop out; however, as of the present date, it can be seen that the program is substantially complete.

Of the various chemicals used in additive manufacture, only sulfur and sulfuric acid are in critically short supply. Most of the new detergent capacity involves petroleum sulfonates, and the use of acid in the production of sulfonates is expected to reach 180,000 tons, or the equivalent of about 60,000 tons of sulfur this year. Consumption in 1950 was about 11,500 tons of sulfur equivalent. Through arrangements with the National Production Authority, PAD so far has been able to maintain supplies of sulfur and acid to additive manufacturers.

Of the chemicals used in the refining of lubes, again only sulfuric acid is critical and PAD has made every effort to see that refiners obtain sufficient supplies for normal operations. Phenol and furfural for solvent refining are adequate now and additional manufacturing capacity is under construction to meet the additional needs. Benzene and toluene are available and, while methyl-ethyl ketone for dewaxing may become a little short, several major producers are planning expansions. Capacity for absorbent clays has also been increased. In short, I am glad to say everything seems to be well in hand except additional solvent refining capacity.

You will note that I have not referred once to any military petroleum products. That is because petroleum products for the military are essentially the same as petroleum products for civilian use. I do not mean to underestimate the technical and specification differences between military and civilian petroleum products, for they frequently raise problems for refiners trying to supply the military. Still, it is basically true that the products the military wants are the same as those the civilian wants. And this is not surprising when you reflect that petroleum is the basic source of mobile power in our economy, and that the demands for fuel will be similar whether the powerplant is hitched to a civilian or military vehicle.

This brings out one very significant point: that it is impossible to consider the question of military petroleum supply independently of the question of civilian supply. There is only one petroleum industry, only one supply of crude oil, only one national productive ability for gasoline and the other petroleum products. The use of those products must be considered as one whole. The question of gasoline for military vehicles cannot be separated from the question of gasoline for essential civilian vehicles. The question of aviation gasoline is one of a piece with the question of gasoline for civilian aircraft.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Questions from the Audience . . . and Davis' Answers

D. P. Barnard, Standard Oil of Indiana—Assuming steel is available, can petroleum producers keep up with increased demand?

Davis—If the oil industry gets the 10 million tons of steel per year now allocated to it, peacetime volume requirements can be met. PAD's present program calls for the drilling of 25,000 wells in the last half of 1952 and 55,000 wells in 1953. This is more than ever before.

Success of the program depends, of course, on the availability of steel in the needed forms. Some additional tubular capacity will come into production later this year, but the program requirements are expected to be somewhat in excess of the available production.

An additional 19,000 miles of pipe line will be installed and refinery capacity is scheduled to be increased at the rate of 500,000 bbl per day during the 18 months beginning July 1, 1952.

Even so, in the event of all-out war, there will have to be an immediate curtailment of gasoline for civilians. Residual fuels will be short, but no immediate difficulty with respect to distillate fuels is anticipated.

Barnard—What are the prospects for attaining 96 octane number in premium-grade motor gasolines by 1955?

Davis—There's no reason why the facilities to produce fuel of such antiknock quality should not be available, providing that there is sufficient economic incentive—and the materials to build the facilities.

Estimates are that catalytic reforming capacity will be increased 250,000 bbl per day during the next two years. And increases in catalytic cracking facilities will result in over 3 million bbl per day of such capacity in 1953. Besides, TEL production is being increased.

What with catalytically processed base stocks and readily available TEL, motor gasoline quality should be no problem in peacetime.

Gerthal French, Richfield Oil Corp.—Is the trend likely to be toward 108/135 aviation gasoline and away from 115/145?

Davis—A new model of the Pratt & Whitney R2800 engine, the R2800 CB-17, has been developed for operation on 108/135 aviation gasoline and is now being flight tested. The CB-17 on 108/135 fuel gives about 150 hp more power than the CB-16 on 100/130. In the DC-6, this power increase will permit an increase of $2\frac{1}{2}$ tons in payload.

Besides, the 108/135 contains 1.6 cc less TEL per gal, which operators hope will lessen maintenance needs.

Base stock for 108/135 is about the same as that required for 115/145. There would be no significant difference in productive capacity, as compared to that grade, but the loss in production as compared to 100/130 would be substantial.

If the new engine-fuel combination proves to be a success economically it will probably still be $1\frac{1}{2}$ to 2 years before demand for 108/135 aviation gasoline rises significantly.

Titanium:

Expensive Weight Saver

New metal can go into parts for aircraft jet and piston engines. But designers must watch for some of its properties. Price per pound and fabricating cost are bound to retard use of the material.

H. H. Hanink, Wright Aeronautical Division, Curtiss-Wright Corp.

Based on paper, "Application of Titanium to Aircraft Engines," presented at SAE National Aeronautic Meeting, New York, April 21, 1952.

TITANIUM performs with flying colors when it comes to saving weight in reciprocating and gas turbine aircraft engines. That's what preliminary studies of titanium parts for these powerplants show. But there's still a big question mark on some of the material's properties, and the metal's present high cost also has to be reckoned with.

Piston Engine Uses

Where does titanium fit into the piston engine picture? It can best be put to work in alloys of equal strength replacing steel alloys now used in the crankshaft and connecting rods. It not only can save about 40% in dead weight, but it'll also increase the saving in the connecting rods by substantially reducing the weight of crankshaft countershafts.

Suppose we take as our guinea pig engine an 18-cyl piston powerplant. This engine is rated at 3500 hp for takeoff, has a dry weight of about 1 lb per hp, and has three exhaust-driven turbines which recover residual energy from the exhaust and feed it back to the crankshaft.

The crankshaft for this engine is a three-piece assembly with front, center, and rear units. The front and rear pieces carry the counterweights. The propeller shaft and front crankshaft are coupled through a planetary reduction gear with the drive gear splined to the crankshaft with tight-fitting splines which are noncase hardened. In the crankshaft center section, the master rod bearing journals and antifriction bearing support pieces are carburized for added resistance to wear, scoring, and chafing.

The alloy steel used for all main shaft parts, except the crankshaft center, is AMS 6415 (SAE 4340), heat-treated to 285 to 321 BHN. The crankshaft center is AMS 6260 (SAE 9310) carburizing steel with a core hardness of 290 to 375 BHN and a minimum hardness of Rockwell C 58 on carburized surfaces.

Three titanium alloys are adequate substitutes for these propeller shaft and crankshaft steels from the standpoint of comparative tensile strengths at the low operating temperatures involved. Their specific tensile properties are compared with equivalent alloy steels in Table 1.

Things Unknown

Substituting these titanium alloys for the steels now used in main shafting adds up to a potential weight saving of about 77 lb. Before this attractive weight saving becomes a reality, some important functional questions must be answered. Among them are:

1. Can the well-known tendency of titanium toward cold welding, or picking up, be overcome satisfactorily in spline teeth and clamp joints?

2. While titanium can be surface hardened by treatments such as oxidizing and carburizing, will surfaces so treated show enough resistance to wear and chafing?

3. How will the low modulus of elasticity of titanium (a little over one-half that of steel) affect the natural frequencies and deflections of the shaft assembly?

Full-scale engine tests probably can best answer the first and third questions. Laboratory research on the second one now is under way; but the lack

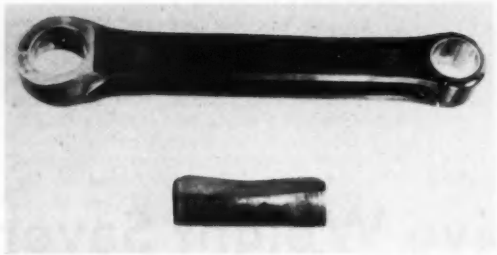


Fig. 1—Shown above is a typical fatigue failure of an articulated rod of titanium after push-pull fatigue testing. Below you can see on the fractured surface that the failure originated from a score mark

of such wear data now should defer use of titanium in the crankshaft center.

That's also the reason for not considering titanium alloys now for many gears, even though it promises a big weight saving. For gears, we must also find out whether surface-hardened titanium offers the same improved fatigue strength at teeth roots as carburized or nitrided steels.

For connecting rods, Ti-175A has enough strength to replace steel, Table 1 shows. Titanium parts would weigh 51 lb less than the steel ones; that includes the counterweight saving.

A titanium connecting rod was fatigue-tested in a push-pull test simulating actual engine conditions. Fig. 1 shows a typical failure after 10,178,000 cycles under loads equivalent to take-off conditions. A

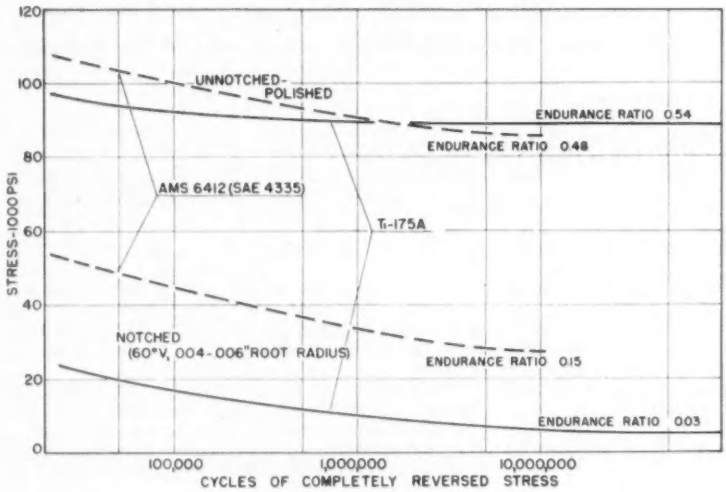


Fig. 2—When titanium is polished and smooth, it has fatigue properties comparable to alloy steel. But notches or scratches in the material make its fatigue strength take a nose-dive. That's what these data show

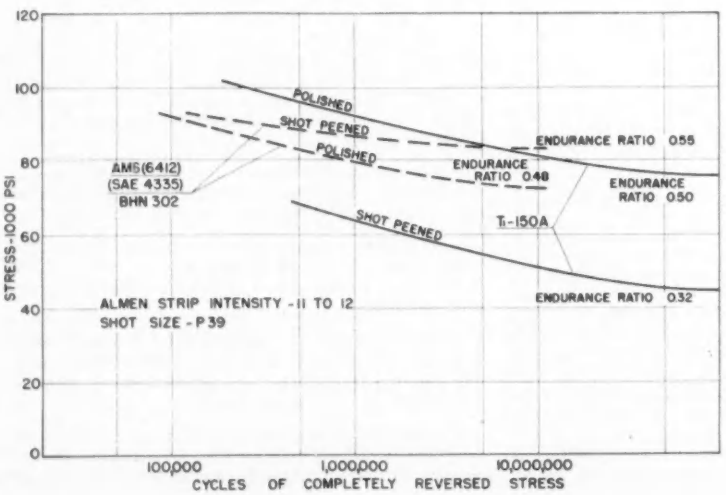


Fig. 3—Shot peening steel improves its fatigue strength. The reverse is true with titanium

Table 1

Room Temperature Tensile Properties of High-Strength Alloy Steels and Proposed Titanium Alloy Equivalents

Material	Ultimate Tensile Stress	0.2% Yield Stress	Proportional Limit	Elongation	Reduction in Area	Brinell
RC-130B (Rem Cru)	150,000	140,000	105,000	15%	40%	320
Ti-150A (Titanium Metals Corp)	150,000	135,000	100,000	16%	40%	320
AMS6415 (SAE4340)	150,000	140,000	125,000	16%	48%	285-321
AMS6260 (AMS9310)	150,000	140,000	125,000	16%	48%	290-321
Ti-175A (Titanium Metals Corp)	175,000	160,000	130,000	15-25%	50%	350
AMS6412 (SAE4337)	180,000	160,000	140,000	15%	50%	331-375

scratch less than 0.001 in. deep initiated fatigue failure. The scratch was made by inserting the bronze bushing in the knuckle pin end. Surfaces of the fracture show the typical fatigue pattern.

Standard steel rods show even better endurance at up to 200% of simulated take-off conditions. That's reason enough to question the notch sensitivity of the titanium alloy used.

Fig. 2 shows that Ti-175A has about the same fatigue strength to tensile strength ratio as the alloy steel used in connecting rods when smooth and polished; but the titanium is only about one-fifth as good in the notched condition.

Our work has indicated that this extreme characteristic does not necessarily show up in all alloys or for all conditions of heat-treatment and notch

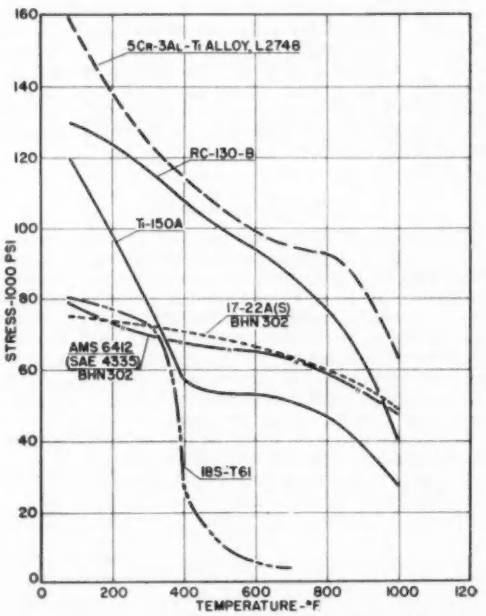


Fig. 4—This chart compares to 0.2% offset yield strength of potential compressor disc materials versus temperature. The data have been adjusted to the density of titanium

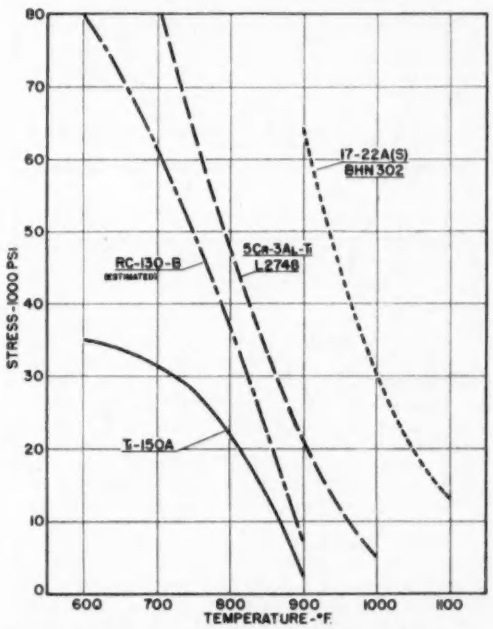


Fig. 5—Shown here are the stresses to produce total plastic strain of 0.5% in 1000 hr plotted against temperature for a heat-resistant ferritic alloy and titanium alloy alternates

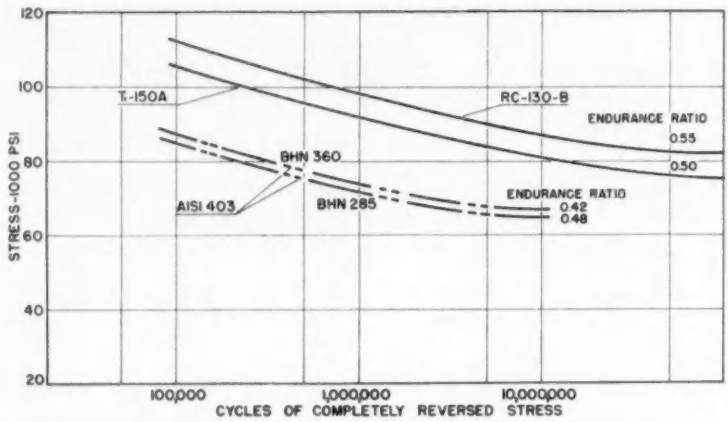


Fig. 6—Compared in these fatigue curves are a typical compressor blade steel (AISI 403) with two titanium alloy alternates in the polished condition

machining practice. But the indications are that none of the titanium alloys equals steel in this respect.

Alloy steel connecting rods hold another advantage over titanium. Their fatigue strength is increased by shot peening. Shot peening has proved detrimental to titanium, fatigue tests showed. See Fig. 3.

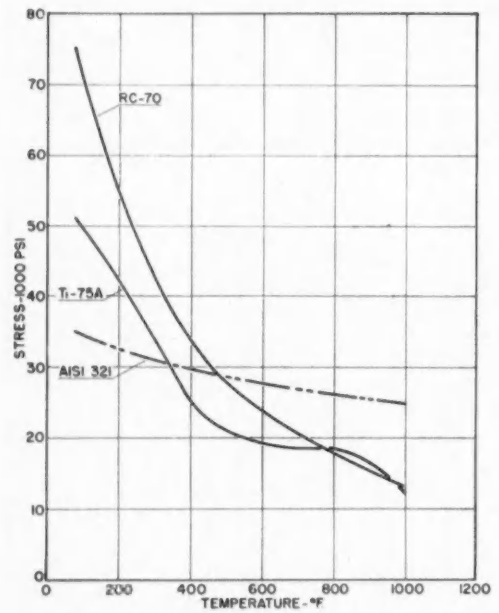


Fig. 7—Shown here is how Type 321 stainless steel compares with two grades of commercially pure titanium on 0.2% offset yield strength versus temperature

Along with the crankshaft center section and case-hardened gears there is a third major steel part which doesn't lend itself to titanium. It's the crankcase assembly. Made from titanium alloys, this assembly would be 70 lb lighter than in steel. But here titanium's low modulus might allow excessive deflection. This would bring excessive chafing under cylinder decks and between the three sections. Fatigue troubles with capscrews, studs, and cylinder barrels also are a likelihood. Lesser weight savings might still be had if there were enough space to allow thicker sections to improve stiffness.

Other small parts—such as rocker arms, push rods, and turbine nozzle supports—must be evaluated in full-scale tests to determine titanium's suitability for them. There is no obvious reason why titanium shouldn't work in these cases. This group of small parts promises a weight saving of about 20 lb if made of titanium.

Jets More Fertile Field

Turbojet and turboprop engines are even more rife with opportunity for weight saving by replacing steel with titanium. The compressor section, a large proportion of total engine weight, has a big chunk of that weight revolving about the shaft. Under proper design conditions, cutting out 1 lb in a compressor rotor blade may save an additional 5 lb in supporting members. And what's more important, the compressor section generally operates at temperatures that titanium can take.

Let's take a look at the potential uses of titanium in the Wright J-65 (Sapphire) turbojet.

For the compressor rotor discs, suitability of titanium alloys depends chiefly on one general design criterion. That's yield strength versus temperature.

Temperature rise through the compressor varies from one engine to another due to compression ratio variations. But part temperatures may range from below zero to 1000 F. Fig. 4 compares the 0.2% yield strength of the six following metals: three titanium alloys, two steel alloys heat-treated to properties

typical of steel discs, and one high-strength aluminum alloy with good heat resistance. All properties have been adjusted to the density of titanium.

Good Showing for Titanium, But . . .

The titanium alloys compare favorably with the steel alloys on the basis of short-time tensile strength. The aluminum alloy becomes inadequate above 350 F. But short-time strength comparisons unduly favor titanium alloy properties. Even at room temperature, these alloys show relatively high creep rates for stresses as high as the 0.2% offset yield level.

Fig. 5 shows the same titanium alloys as in Fig. 4. But compared here is their relationship as to stress to produce 0.5% creep in 1000 hr at temperatures from 600 to 1000 F. None of the titanium alloys shown seems to offer suitable creep strength for compressor discs above 700 F. In contrast to this, any alloy steel can be used on the basis of short-time tensile properties through at least 750 F.

Even then some of titanium's weight advantage over steel may have to be sacrificed. To what extent will depend on the efficiency of the original steel disc design and the minimum section size to which a steel disc may be machined under practical conditions.

It's been found possible to save 121 lb from rotor discs alone of a typical advanced type compressor. That's true despite less than full returns from replacing steel with titanium. This holds only if titanium also replaces steel in rotor blades so as to materially cut disc stresses.

When it comes to considering titanium for compressor blades, fatigue characteristics stand out because of blade vibration. Creep strength also is important for compressor discs because of bending loads on stator blades and both bending and centrifugal loads on rotor blades. A reasonable limiting temperature for titanium compressor blades seems to be 700 to 750 F based on creep characteristics, even though blade length and generally blade stresses diminish toward the high-temperature end of the compressor.

Notch sensitivity of titanium alloys calls for care here as with connecting rods for piston engines. Titanium alloy blades should have a good surface finish. Well polished blades give good fatigue strength. Fig. 6 shows that. It compares two titanium alloys with a typical stainless steel used for compressor blades.

The apparently detrimental effects of shot peening carries over here. It may also imply that titanium blades may be overly sensitive to nicks and scratches from handling or engine operation.

To the good weight/strength ratio and corrosion resistance of titanium blades can be added a third plus value—lower fatigue stresses. That's because of their lower elastic limit than steel. While vibration amplitude would be greater than for steel for the same exciting conditions, it probably wouldn't grow to where bending stresses would equal those for steel blades.

Other Jet Uses

Commercially pure titanium may also be used in turbojet or turboprop combustion chamber or compressor housings, bearing supports, and heat shields made from sheet metal. Here is how titanium stacks up against carbon steel instead of stainless for alloy conservation: it is lighter, not strategic, and needs no protective coating. Through 600 to 700 F it may usually be substituted for either carbon steel or stainless with a net saving in weight.

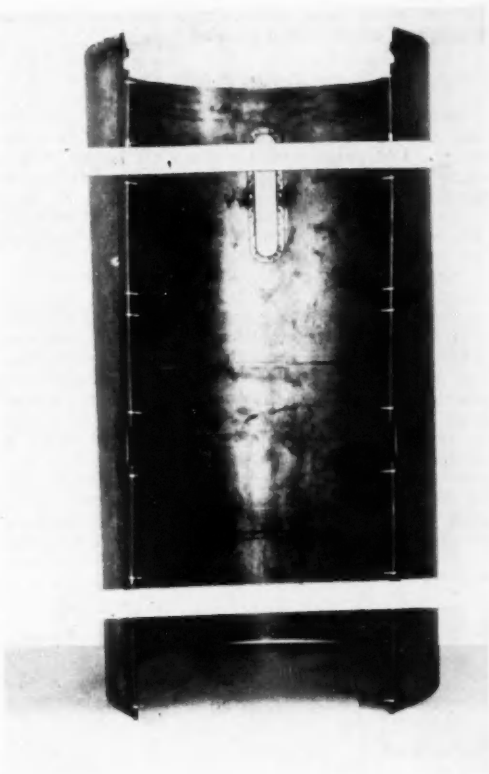


Fig. 8—Commercially pure grades of titanium are easy to weld and to form. This is a welded fairing formed from Ti-75A sheet

Fig. 7 compares two types of commercially pure titanium with Type 321 stainless with respect to yield strengths through 1000 F. Again creep properties—even at low temperatures—may control the design stress limits for titanium. In some cases, where sheet metal structures are designed mainly for stiffness, titanium's low modulus may limit full weight savings.

Fig. 8 shows a large fairing made of 0.050-in. Ti-75A. The extensive and successful use of spot and fusion welding as well as relatively severe bending show that commercially pure titanium, unlike its existing alloys, is easy to weld and form. Flash welding also has been successful on a commercial scale. So there is no technical barrier to fabricating sheet metal engine parts calling for welding of

formed sheet metal to integrally formed forged or rolled and flash welded flange rings.

The Dollar Drawback

Brush aside the technical problems with titanium and you still come face-to-face with the cost obstacle. Compared with low-alloy steels the stuff is terrifically high priced as well as expensive to machine and to grind.

Table II shows some typical engine part weights, weight savings by using titanium alloys, and cost comparison of finished parts where available.

Titanium alloys sell for about $3.50 per lb today as compared to about 8¢ per lb for alloy steel. So titanium's high price accounts for most of the cost differential. Experience also shows that when you make parts of titanium alloy in place of steel, forging costs go up about 50% and machining costs about 100%. The machining problem is aggravated with light-weight aircraft engine parts, as shown in Table II. That's because the forgings weigh so much more than the finished parts.

At present, the price paid for every pound saved by switching from steel to titanium is from $50 to $100 for heavier and easy-to-make engine parts, and from $140 to $240 for light, precision parts such as compressor blades. These figures are not shown to discourage use of titanium in aircraft engines. They point up the pressing need for cheaper production of titanium metal and rapid development of suitable machining techniques.

Chances are good that rising production volume and eventual development of new production techniques will substantially reduce the cost of titanium in the near future. We are not so hopeful that machining costs will ever be brought down below those for austenitic stainless steels. But this isn't too severe a handicap. Many gas turbine parts are now being made from stainless alloys. The situation for forging costs is about the same as for machining costs.

Some day we may find that the cost of titanium's benefits will become reasonable. It may happen after aircraft engine producers have done the great amount of development work needed, which in turn will result in the greatest number of useful applications of titanium and its present alloys. It is with this in mind that we should proceed as rapidly as possible with our share of the over-all effort.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 2

Cost and Weight Analysis of Selected Titanium Aircraft Engine Parts

Part Name	Material	Approximate Weight of Finished Part (in lb)	Ratio of Forging Weight to Finished Weight (Approximate)	Approximate Cost of Finished Part	Approximate Weight Savings from Use of Ti per Part and per Engine	Approximate Cost of Weight Savings per lb
Propeller Shaft	AMS 6412 Titanium Alloy	53.0 32.0	3.0	$ 161.00 1155.00	21 lb	$ 47.00
Crankshaft Front	AMS 6415 Titanium Alloy	45.0 27.0	5.0	132.00 1451.00	18 lb	73.00
Crankshaft Center	AMS 6260 Titanium Alloy	61.0 37.0	2.5	142.00 1097.00	24 lb	40.00
Crankshaft Rear	AMS 6415 Titanium Alloy	32.0 19.0	3.0	74.00 631.00	13 lb	43.00
Articulated Rod	AMS 6412 Titanium Alloy	3.0 2.0	3.5	16.00 98.00	1 lb/part 16 lb/engine	82.00
Master Rod	AMS 6412 Titanium Alloy	17.0 10.0	6.0	87.00 705.00	7 lb	88.00
Rocker Arm	AMS 6322 Titanium Alloy	1.0 0.6	2.0	9.00 31.00	0.4 lb/part 14 lb/engine	55.00
Turbine Support	AMS 6322 Titanium Alloy	3.0 2.0	8.0	50.00 246.00	1 lb/part 3 lb/engine	194.00
A Typical Compressor Rotor Disc	AMS 6342 Timken 17-22A(S) Titanium Alloy	25.0 14.0	5.0	93.00 737.00	11 lb/part 143 lb/engine	58.00
A Typical Compressor Stator Blade	AMS 5613(AISI403) Titanium Alloy	0.06 0.04	2.0	3.00 6.50	.02 lb/part 30 lb/engine	175.00
A Typical Compressor Rotor Blade	AMS 5613(AISI403) Titanium Alloy	0.10 0.06	6.0	5.00 14.00	0.04 lb/part 28 lb/engine	238.00

Synchronized Brakes for Truck-Trailer Units

J. George Oetzel, Vice-President—Engineering, Warner Electric Brake & Clutch Co.

Based on paper, "Synchronization of Brakes on Multiaxle Truck-Trailer Trains," was presented at the SAE Annual Meeting, Detroit, Jan. 15, 1952. This paper was published in full in the April SAE Quarterly Transactions.

SYNCHRONIZATION of the brakes of multiaxle truck-trailer combinations is necessary, not because it means shorter stopping distances, but because it minimizes that short but critical time in which a jackknife can get beyond control.

For example, if the drive axle brakes of a semitrailer unit build up faster than those on the front axle or the trailer, on slippery pavement the drive wheels are apt to slide suddenly to one side, producing a jackknife. This type of jackknife happens so quickly that the driver doesn't have time to correct for it by steering. In such cases, the driver will usually claim he "lost steering control."

If the trailer brakes build up first, a jackknife can still result, but it takes place slightly more slowly, giving the driver a better chance to recover by gunning the engine and/or releasing the brakes. This happens when the trailer wheels reach a slide with the tractor just "holding back." The rear of the trailer then starts to swing over to one side, or "come around," as the driver says. He can see this in the mirror, and it occurs slowly enough so that he has a good chance of bringing the trailer out of it before it reaches jackknife proportions . . . that is, if it hasn't swung in the way of opposing traffic or into a culvert.

Thus, it appears that if perfect synchronization cannot be obtained, of the two evils, it is better to have the trailer brakes build up first—if only to ensure that they don't build up after those on the drive axle.

Tests on Ice

Tests on ice indicate that for a tractor-semitrailer unit, a critical angle is often reached between tractor and trailer in 2–3½ sec, and that recovery efforts must be begun before the end of this period if recovery is to be effective.

On ice, full brake power is not needed to cause a slide, so the jackknife can even begin before the tractor brakes reach full power.

The critical period in which a jackknife can begin is possibly three-quarters of the time before the trailer brakes reach full power. Moreover, the difference in time for tractor and trailer brakes to reach full power is critical regardless of the road coefficient of friction.

To make matters worse, a jackknife must develop to a certain point before it is evident to the driver. Then his reaction time begins, after which there is brake response time before recovery begins to be effective. All of this must take place in the 2–3½ sec before the critical angle is reached.

There are so many variables that it is hard to evaluate these factors, but let us assume that:

1. It takes 1–1½ sec for the jackknife to develop sufficiently so that the driver is aware of it.
2. Driver reaction time is ½–¾ sec.
3. Brake response time is ½ sec.

This totals 2–2¾ of the critical 2–3½ sec and is close enough to show how little the assumptions need to be in error to make it doubtful that any such jackknife can be avoided. This further illustrates the importance of having tractor and trailer brakes build up as one brake.

When you consider that human reaction time for a comparatively few persons may be as short as ¼ to 1/3 sec, but for most is about ¾ sec, you can better appreciate the importance of brake synchronization.

We think of the hydraulic brakes on passenger cars as acting fast—almost instantaneously. Actually, even when the driver is "jabbing" the brakes in an emergency application, an appreciable interval elapses between the time his foot touches the pedal and when the brakes begin to go to work. During some additional time the pedal pressure and the brakes are building up to full power. It takes time for muscle force to build up, too, and the brakes must follow—not precede—the muscle force.

When vacuum power is added to hydraulic brakes, another element is added in the buildup time. Air brakes or vacuum-hydraulic brakes require less muscle-power, nevertheless, there is a time element in opening the valve, and other time elements in various parts of the system. Even electric brakes are not instantaneous, but their inherent time element is short enough to be within the muscle time in operating the controller, or to follow a controller actuated by hydraulic or air pressure.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Oil Has Small Effect on

THE lubricating oil is responsible to only a small degree for the problems associated with combustion-chamber deposits. Such is the conclusion that appears as the result of a series of closely controlled laboratory engine dynamometer tests in which oils of several base stocks and with varying additive types in several concentrations were used. Fuel type and tel content, as well as engine design, were also varied in some of the tests.

An automatic cycling operation was used that incorporated idling to high-speed, high-load conditions with rapid acceleration and deceleration. Although it was recognized that this operating schedule did not simulate automotive operation, it was felt that this cycling condition approximated the two extremes encountered in service. Further, previous experience had indicated that laboratory engine octane requirement increase values obtained by this method were of the same general magnitude as those normally encountered in passenger cars, that the time to combustion-chamber equilibrium conditions and quantity of deposits were comparable to those reported in road test investigations.

The factors studied in the tests were octane requirement increase, spark-plug performance, power loss, and exhaust valve burning.

Octane Requirement Increase

Changing the additive type at the MIL-0-2104 level in a constant base oil stock resulted in a maximum variation in octane requirement increase of 3.8 octane numbers.

When the additive concentration was increased from 0 to that of Supplement 1 oils, the change in octane requirement increase was 4.6. When the concentration was increased from 0 to that of MIL-0-2104, the change was 3.7 octane numbers. When the variation in additive concentration was from MIL-0-2104 to Supplement 2 level, there was no appreciable change in the octane requirement increase.

Midcontinent, solvent-refined oils, a conventionally refined naphthenic oil, and a synthetic base oil were blended with a common additive in MIL-0-2104 concentrations. Engine tests with these oils showed no appreciable differences in octane requirement increase. Contrary to the data published by other workers, the naphthenic oil blend exhibited no exemplary characteristics in suppressing octane requirement increase. It may be, however, that some of the beneficial effects reported by others have been masked in the present tests by the addition of detergents. As it is probable that the predominant amount of these oils will receive additive treatment in their manufacture, it is felt that the comparative base-stock-additive approach is justified.

MIL-0-2104 oil used with leaded (1.62 ml tel per gal) gasoline gave an octane requirement increase of 10.6, but with propane gave an increase of 3.1.

Supplement 1 oil used with leaded (2.86 ml) dirty gasoline gave an increase of 15, compared with 2.5 with an unleaded, clean gasoline.

No relationship was found when the weight of combustion-chamber deposits and the octane requirement increase were compared with the ash

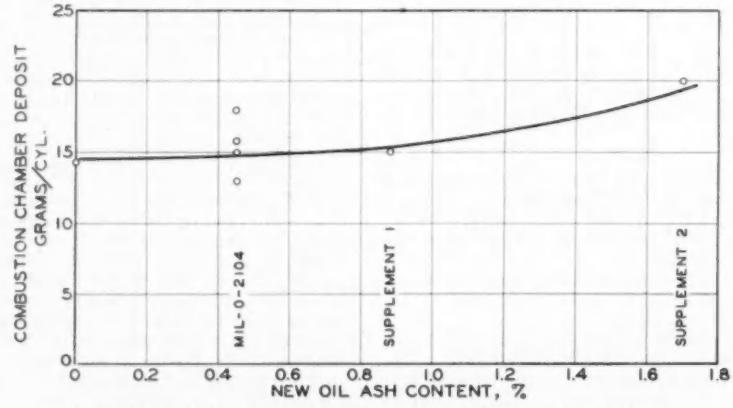


Fig. 1—Quantity of deposits versus new oil ash content—Midcontinent refined base oil

Combustion-Chamber Deposits

D. E. Carr, L. A. McReynolds, S. C. Britton, and R. E. Linnard

Research and Development Department, Research Division, Phillips Petroleum Co.

Based on paper "An Engine Laboratory Study of Motor Oil Characteristics as One of the Factors Influencing Combustion-Chamber Deposits" presented at the SAE Annual Meeting, Detroit, Jan. 17, 1952.

content of oils containing various additives. In fact, a substantially ashless detergent gave more deposit, although less octane requirement increase, than the additive blend having the highest ash content. When the same additive was used, however, there appeared to be a slight upward trend in deposits as the additive concentration was increased to Supplement 2 level, as shown in Fig. 1.

Oil consumption, intentionally increased to promote the transfer of oil to the combustion chamber, did not appear to have any significant effect on the octane requirement increase or the weight of deposits. In four tests with the same fuel and additive oil, oil consumption varied almost two-fold (from the equivalent of 190-385 mpg) without influencing the octane requirement increase or the quantity of the deposits laid down.

Spark-Plug Performance

In these tests oils containing certain additives tended to cause spark plugs to approach misfiring conditions more rapidly than did others.

The rate of deposit buildup on the core ceramic varied from 0.0025 to 0.0043 g per hr for the additive oil tests with a leaded fuel, but was only 0.0005 g per hr for the additive oil test when LPG was the fuel.

Plugs with performance rated as poor did not show unusual rates of deposit buildup. Thus, it seems logical to assume that the electrical properties of the deposits at plug operating temperatures are much more significant than the actual extent of deposits laid down on the ceramic unless, of course, they are of unusually great volume.

Changing the additive type at the MIL-0-2104 level in the constant base oil stock resulted in a variation in plug performance from poor to very satisfactory. As additive concentration was increased in the same base stock, spark-plug performance become somewhat less satisfactory.

Power Loss

Comparative power loss data obtained in this study do not appear to be of much significance. The power output values associated with the removal of deposits at the end of testing actually varied from an increase of 7.3 hp to a loss of 7.4 hp. The losses associated with deposit removal were, however, exceptions to the rule, as power output increased in all instances following the complete removal of deposits at the end of the test. Generally, some degree of power loss was noted with increased operating time.

Exhaust Valve Burning

Time to exhaust valve failure varied from 96 hr to over 450, some additives at MIL-0-2104 concentration being much more critical in this respect than others in concentrations up to Supplement 1 level.

A secondary effect of valve burning was found to be a further increase in octane requirement increase, and, on this basis, the maximum octane requirement increase variation caused by differences in additive composition could be considered to be as much as 15.2 octane numbers.

General Conclusions

It appears that, under the severe operating conditions represented by the laboratory tests, the ash-forming constituents in a lubricating oil tend to function as modifiers of the lead compound deposits in the combustion chamber and, as such, tend to affect spark-plug and valve performance to a greater degree than octane requirement increase or power output.

In addition, it appears that combustion-chamber deposits and their effects tend to reach an equilibrium that is only slightly affected by major variations in fuel tel content, oil composition, or oil consumption but that is probably more sensitive to variations in engine design and method of operation.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Based on Discussion By William A. Howe

Gulf Oil Corp.

LARGE-scale field tests conducted by Gulf over the past few years have produced results that are in general agreement with the data presented here. More specifically, the Gulf tests also show

that variations in lubricating oil base stock, as well as the additives used—both as to type and quantity—do not vary greatly in their influence on octane-number requirement increase.

In their paper, the authors suggest that any beneficial effects on octane requirement increase of naphthenic base oils might have been masked in their tests by the addition of detergents. The data of the Gulf tests, where no additive was used in the naphthenic oil, indicate that, at least in normal passenger-car driving, the source of the base oil is of no significance.

The Gulf tests also show that there is little difference in power loss between oils containing detergent-dispersant additives and those with no additive or containing only an oxidation inhibitor. With regard to oils containing detergent-dispersant additives, the level or degree of additive concentration appears to have little significance in power loss.

In summary, it is believed that high additive oils will not contribute to excessive octane requirement increase or to decreased valve or spark-plug life. On the contrary, there is some evidence to show that certain additives in high concentrations may increase valve and spark-plug life under certain conditions and to a small degree reduce the octane requirement increase.

Air Conditioning Systems . . .

. . could be advanced by using airline operators' experience in design development. And the Martin 404 is a case in point.

BASED ON PAPER BY **E. S. McCarthy** Trans World Airlines, Inc.

THERE are essentially two distribution systems in the air conditioning system of the Martin 404 which represents the joint efforts of the Glenn L. Martin Co., Eastern Air Lines, and Trans World Airlines. There is a fresh air supply system and a recirculation system which are integrated and to which special features have been added to serve several functions. Valves permit connecting the elements of the overall system in different ways to get the configuration required for each of the several operating conditions.

The prime condition is normal pressurized flight. In such flight, fresh air is supplied by a compressor. The air is directed to an air cycle refrigeration system, the amount of heating or of cooling being set by the position of a bypass valve which causes air to flow through a secondary compressor, heat exchanger, expansion turbine and water separator, or alternately, to enter a duct bypassing these elements. The air is then discharged into the cabin through an overhead duct running the cabin length. A separate duct is used for introducing refrigerated air in order to reduce the reheating of the cooled air before discharge. The cooling airflow for operation of the secondary heat exchanger during flight refrigeration is obtained from a ram source.

The heating system includes two combustion heaters and two ventilating fans in parallel. Only one of each is used in normal pressurized flight. When more heat is required than the compressor can supply, heat is introduced in the recirculating air stream and this heated air is discharged into a warm wall system. The duct is buried in the hat rack and the air flows up and down from this point to discharge points at the top of the wall and to outlets under the seats.

Air flows into the space beneath the deck through a single large exhaust opening in the rear of the cabin. At this point some air is dumped through the pressure regulating valves, while the remainder flows forward through the belly, warms the baggage department and returns to the recirculating fans. This scheme simplifies sealing the compartment for CO_2 retention, yet keeps the contents above freezing. No special provision is made for separate discharge of exhaust air from the galley because experience has shown it to be unnecessary. A separate discharge is provided for the lavatory.

Cabin temperature control is automatic throughout the entire temperature range of refrigeration and heating. The control includes a conventional bridge circuit using temperature sensitive resistance elements exposed to cabin temperatures. Flight station temperature is controlled by a valve which mixes warm and cool air. The crew handle this valve through a mechanical push-pull control.

Hot air for the windshield comes from the cabin heat source, since it is believed that windshield anticing heat should not be taken from the airfoil heat source.

One objective sought in design has been to insure passenger comfort by preventing delays in schedule. To this end design is such that flight need not be halted, nor repairs made en route, because of any common malfunctioning of the system. If, for example, one heater or its related blower fails, the other unit can be turned on. If a compressor goes bad, it can be disconnected by flipping a switch, and air for heating and ventilating will come from a ram source. Sections of the overall system have been segregated into segments which are essentially independent electrically. Any part that doesn't work is the part that has gone wrong and trouble-shooting is aided immeasurably.

Experience tells that ground operation of heating systems should be independent of the engine; that refrigeration equipment is unjustified unless it can be ground operated with engines turning at speeds

reasonable for taxiing and ground holding. It is also believed that future design should strive for a system free from other functions and capable of operation independent of engines or ground equipment. Further development of small auxiliary gas turbines may be the key to such simple, independent air conditioning systems. (Paper, "Improved Passenger Comfort Through the Application of Airline Experience to Air Conditioning System Design," was presented at SAE National Aeronautic Meeting, New York, April 21, 1952. It will be printed in full in SAE Quarterly Transactions. It is also available in full in multilithographed form from SAE Special Publications Department at 25¢ a copy to members and 50¢ a copy to nonmembers.)

Based on Discussion

By Paul C. Scofield
AiResearch Mfg. Co.

IF the accessory manufacturer is permitted to deliver an end result, he can balance primary compressor versus heat exchanger versus bootstrap refrigeration units to arrive at the most economical arrangement. Some portions of the Martin 404 system came from collaboration between air frame and accessory manufacturer to get a desired end result. No rule can be set up for air cycle system arrangements to obtain maximum cooling for minimum weight and space because of the necessity to coordinate with the pressurization system. Both refrigeration and pressurization must be served by the same compressor, sometimes individually, at other times simultaneously.

It is not necessarily true that the greater the primary compressor the greater the refrigeration capacity. It can be determined for any given set of components only after careful analysis. It usually can be shown that a lesser flow at somewhat lower refrigeration unit discharge temperatures will result in greater capacities.

Dehumidification—not mentioned by the author—is very important. It is generally conceded that high humidity causes greater discomfort than high temperature in the high temperature ranges, and within limits. Commercial evaporative coolers, for example, provide low enough dry bulb temperatures, but fail to give comfort except in extremely arid climates. As transport air conditioning advances summer dehumidification will be a necessity.

By B. L. Messinger
Lockheed Aircraft Corp.

COMPLEXITY is not an accident. It is a direct result, and nearly proportionate to, the number of functions and degrees of flexibility which are demanded when the system is conceived. Airline passenger service and operations branches want the maximum in comfort and flexibility and therefore ask for a complicated system whether they know it or not. Maintenance wants a simple system, hence a more limited comfort level. The design engineer must arbitrate or compromise this conflict of objectives.

The Martin 404 would seem to satisfy passenger comfort, but it remains to be seen how unhappy it makes the maintenance people. The use of cool exhaust cabin air as a coolant air stream for a secondary aftercooler used during ground refrigeration is unique. The practice of distributing undiluted air directly to the cabin by a bootstrap unit may prove to be undesirable since it could lead to severe fogging of the cabin in humid climates. The large amount of bulky equipment installed in the forward underfloor area would appear to sacrifice valuable potential cargo space.

By W. W. Reaser
Douglas Aircraft Co., Inc.

THE author is to be congratulated on his desire to have various systems segregated to achieve "autonomy". It's unfortunate that the principle was departed from when the engine fuel system was used to supply fuel under pressure to the cabin heaters. The separate fuel pump creates a design problem from a reliability standpoint, but using the engine system might shift the trouble to another spot, mainly to the engine booster pump. Several cases of feathering engines have been due to malfunctioning of the heating system when the main engine fuel pumps were used to supply fuel under pressure to the heaters.

Exhausting cabin air across the heat exchanger appears clever. But since a pressure drop of 3 to 4 in. of water across the exchanger is equivalent to 300 to 400 feet of altitude at sea level, one wonders how a sudden change in cabin pressure is prevented.

Attractive as is an auxiliary device for powering the air conditioning system, the added weight and complications would seem to make it undesirable unless it can be made as reliable as the main power plant and has comparable fuel consumption so that it can operate independently during all phases of operation.

By Vernon A. Peterson
Airline Pilots Association

IN 1949 the Association requested that air in pressurized cabins be tested for purity to see if it could explain the fatigue felt by pilots. The rate of ventilation was calculated from the presence of carbon dioxide. In one type of craft, values running from 4 to 6 cu ft per min per person were found. The rate of change complied with CAA regulations but the pilots were not getting adequate ventilation. The recirculating fans had fooled them into believing everything was all right.

Reasonable standards for the crew compartment, as the pilots see it, call for at least a 30 cu ft per min per person flow of fresh air properly heated, with controllable outlets to avoid direct drafts. No part of this air should be recirculated air; it should come direct from compressor or refrigerator. This means using a separate heater for air going to the crew compartment. There should also be a device to show the true rate of ventilation and provide a continuous recording of the system's performance.

Maximum allowable carbon monoxide should be related to altitude and flight duration. For maximum flights of 4 hr or less at altitudes of 5000 ft or lower, the value should be 0.002%; for flights of over 4 hr duration, or shorter duration if at higher than 5000 ft altitude, the permissible value should be 0.001%.

Here's How to Hike

PISTONS, rings, and cylinders still represent—with few exceptions—the life limiting components of present-day engines. These parts wear out faster, break more often, stick and seize more frequently than any other engine parts. Consequently, they are the most costly parts from the engine operators' standpoint.

What measures can be taken to assure most economical maintenance of these components? We will see . . .

Additive Oils Bad During Run-in

Use of the proper type lubricant, for example, will cut failures due to lack of seating of rings and cylinders during the first several thousand miles of operation of new and rebuilt engines.

Recently there has been a sharp increase in this type of failure which:

1. In heavily loaded engines—critical on cylinder distortion—results in excessive blowby which can cause pistons to overheat, rings to stick, and the piston-ring-cylinder assembly to be scuffed and scored.

2. In engines not heavily loaded—nor critical with regard to cylinder distortion—results in excessive oil consumption for extremely long periods of time, sometimes indefinitely.

A study of the cause of this lack of seating pointed to the use of the high additive lubricants, MIL-2104, Supplements 1 and 2. These lubricants were developed to reduce cylinder and ring wear in heavy-duty automotive type diesel engines, especially in connection with the use of fuels having high sulfur content. But during the last year a number of operators, wanting to use every possible means to reduce operating costs, have used these heavy-duty lubricants in their fleets.

And evidently some of the additives used in these highly fortified oils have the same characteristics as e-p gear lubricants. They form a polar arrangement or metallic plate of the surfaces, effectively preventing metal-to-metal contact and the abrasion of the peaks in the mating surfaces necessary to provide effective seating.

Here, paradoxically, such a good job of keeping the mating surfaces apart has been done that failures are induced. Where these have occurred, the consequences have been very serious, and the operators completely frustrated by their unexpected appearance.

Fortunately, this problem can be easily solved by using a non-additive or a light additive lubricant until initial seating takes place. After this, highly fortified oils can be used to provide the desired improvements expected of them.

Use Sand-Cast Cylinder Sleeves

Sand-cast sleeves are to be preferred over centrifugally-cast ones. The open graphite structure of a sand-cast liner still provides the ideal cylinder surface. Endurance tests recently conducted by one heavy-duty engine manufacturer showed that the ratio of wear was 2.6 to 1 in favor of sand-cast liners.

In some cases, for example, where the sleeve is extremely thin and operating temperatures are high, a centrifugally-cast alloyed material must be used. Otherwise, the temperature differential between the sleeve and the cooled outer cylinder will cause the sleeve to collapse.

Light Interference Fits Best for Dry Sleeves

Best practice for installing dry sleeves is to use either a very slight interference or a slip fit. Interference fits of 0.001 in. or light push fits give less cylinder distortion than high interference fits. This in turn, means less blowby, plus longer cylinder and ring life.

When replacing a sleeve, it's also important to clean the cylinder to assure good contact with the new sleeve. Often hones are used for this operation, but they have the disadvantage of changing the size of the bore. Conventional glaze busters are the things to use. They effectively clean, but don't change dimensions measurably.

Piston-Ring-Cylinder Life

Helmuth G. Braendel, Director of Engineering and Production, Wilkening Mfg. Co.

Based on paper, "Ring, Piston, and Cylinder Assembly," presented at SAE Annual Meeting, Detroit, Jan. 14, 1952.

Conformable Oil Rings a Must

It's important to use conformable oil rings, too.

The life of the ring and cylinder installation is directly proportional to the ability of the oil rings to meter a continuous but thin oil film to the compression rings. And in present-day commercial engines, with their higher specific outputs, it has become increasingly more difficult to provide proper lubrication with the single-piece conventional, stiff, cast-iron oil control ring.

As power load goes up and cylinder distortion increases, it becomes increasingly important to use extremely flexible and conformable oil rings. Fig. 1 shows several of the types currently used.

Chrome Top Rings Pay Off

Chrome top rings are now used on almost every heavy-duty commercial engine . . . and for good reasons. They're much less susceptible to scuffing and resist both abrasive and corrosive wear.

Chrome top rings are universally recommended in rebuilding procedures, except when cylinders are badly worn. In such cases, the extreme hardness of this material prevents seating and may cause premature failure due to blowby.

Resize Pistons by Knurling

Another sound maintenance practice is to resize worn, but otherwise serviceable, pistons to reduce excessive side clearance caused by piston and cylinder wear. Better ring life will be obtained if relative motion between these parts, especially cocking, is reduced to a minimum.

One of the best ways to resize pistons is to knurl both sides of the skirt to at least original specification side clearance. The knurling method provides an interrupted surface on the thrust bearing sides of pistons which makes them very resistant to scuffing.

Pockets of lubricant retained by the knurled sur-

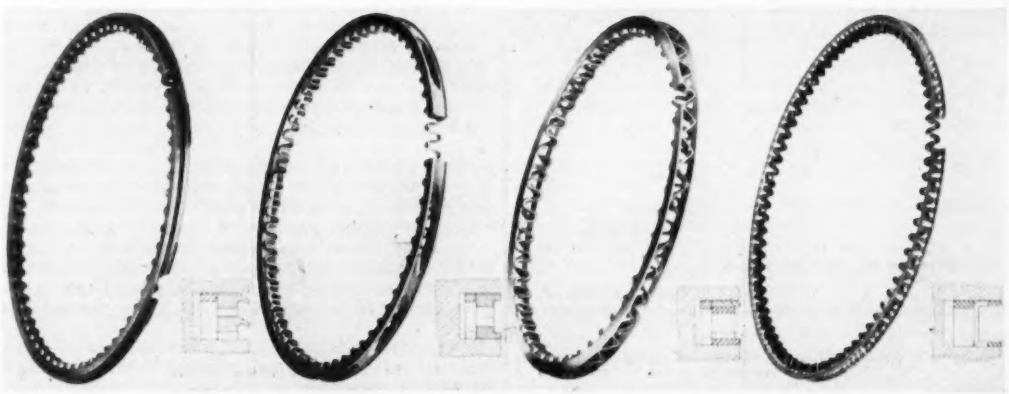


Fig. 1—Typical conformable oil rings used in some present-day high-output commercial engines

faces prevent scuffing to such a degree that closer piston fits can be employed than are possible with new conventionally-finished pistons. This is especially important in rebuilding procedures because it provides a wide margin of safety in regard to piston clearance.

The desirability of these interrupted surfaces from the scuffing standpoint is so great that even original equipment pistons are manufactured with them where economic considerations permit.

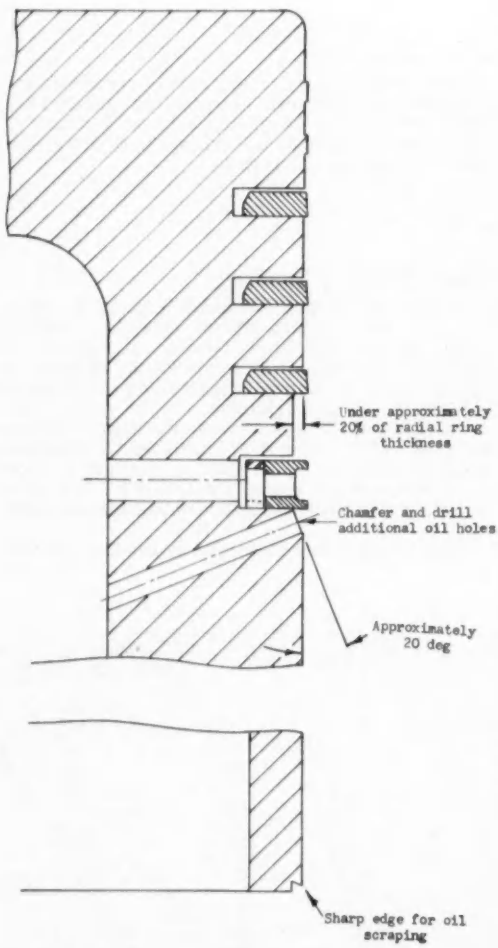

Under approximately 20% of radial ring thickness
Chamfer and drill additional oil holes
Approximately 20 deg
Sharp edge for oil scraping

Fig. 2—Minor piston modifications—easily made during engine rebuilding—greatly improve oil control

Modify Pistons to Improve Oil Control

There are three other piston alterations—easily accomplished during engine rebuilding—which will greatly improve oil control regardless of the type of oil rings used. These three modifications are shown in Fig. 2.

1. *The bottom of the skirt should be left sharp:* This part of the piston has the ability to control as much oil as an additional oil control ring . . . provided the piston is fitted relatively close and the edge is left as sharp as machining will permit. An angle of less than 90 deg is preferable at this point. In the case of some large pistons where handling may damage this edge, a very small undercut will protect it from being damaged. (See Fig. 2.)

The difference in oil control is considerable. The oil ring, which depends upon tension to maintain contact with the cylinder wall, may collapse due to high hydrodynamic pressure built up by excessive accumulations of oil. But the sharp piston skirt will strip the excess oil without collapsing.

2. *An undercut or bevel should be provided just below the oil-control groove, together with passages to the inside of the piston:* This will provide both lands of the oil control ring with abundant drainage.

This is important. If there isn't effective drainage of the relatively large quantity of oil that collects on the lower land as the piston moves downward, the hydrodynamic pressure built up will push the land from the cylinder wall. Since most oil rings are of the single-piece double-scraper type, the upper land will likewise be lifted from the cylinder wall after the ring has been subjected to a slight amount of twist. Lack of drainage for the lower land, therefore, impairs the ability of both lands to control or meter the oil.

3. *The land between the oil-control ring and the lowest compression ring should be undercut approximately 20% the radial thickness of the ring:* The compression rings in a properly designed ring combination must control the oil metered to them for their lubrication. This simple design change helps them perform this function. It provides a reservoir for the oil scraped on the down-stroke by the lowest compression ring. On each subsequent upstroke, the oil collected may flow back to the inside of the piston through the side clearance of the oil ring.

This piston alteration, alone, can be responsible for an improvement in oil control of as much as 50%. And in one heavy-duty truck engine it resulted in an improvement of close to 100%.

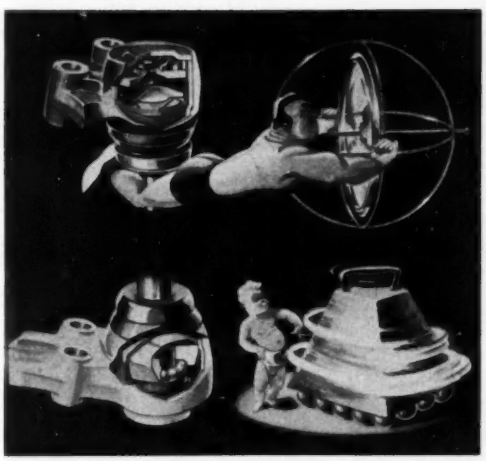
In short, these minor piston modifications throw a major portion of the load of oil control onto the pistons, and make it unnecessary to use rings of extremely high unit pressure to obtain desired results.

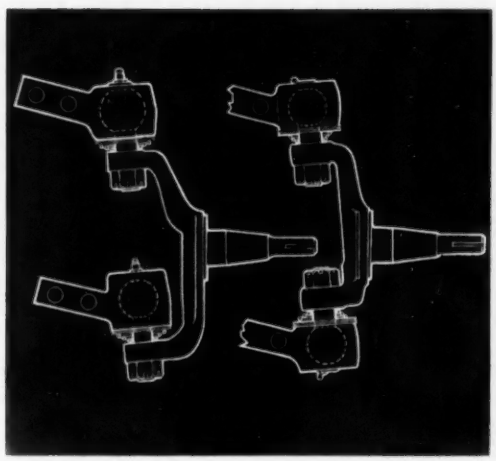
(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Dept. Price 25¢ to members, 50¢ to nonmembers.)

Case History: Ball-Joint Suspension

James H. Booth, Thompson Products, Inc.

Based on paper, "The Application of Ball Joints to Front Suspensions" presented at SAE Annual Meeting, Detroit, Jan. 18, 1952.





1. Object— The Thompson Products ball-joint suspension is unique in two respects. Its sockets perform separate functions. The lower ball joint carries the load on a ring of balls . . . the upper one dampens out gyroscopic action at the wheels.

How did this novel design come into existence? Let's take a look. . . .

At the start of its program, Thompson Products designed a ball-joint suspension somewhat along the lines of development history.

The first test car was equipped with ball joints having a full ball on the end of the stud. As expected, too much steering resistance resulted.

2. Mounting— The method of mounting these first sockets did, however, eliminate one objectionable feature. The usual method of mounting the lower stud compressively was reversed and the stud was hung on the taper. This removed a large mass from the spindle support and improved the geometry of the design.

It was then suggested that the load-carrying socket should provide a free turning mechanism in the steering motion, with resistance required in the steering motion concentrated at one point in the upper socket.

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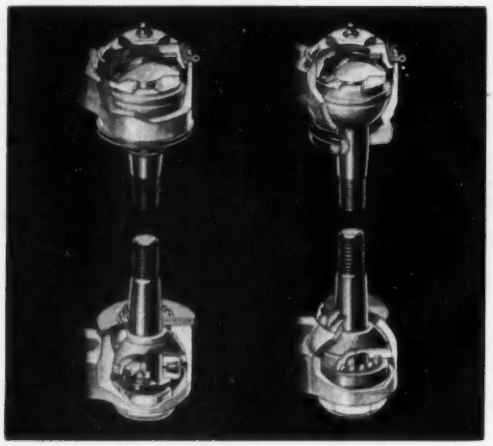
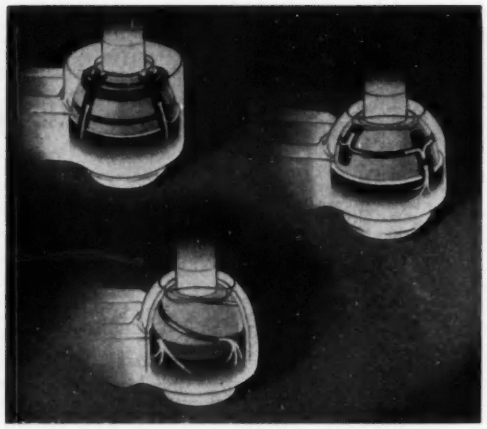
Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members; 50¢ to nonmembers.



3. Seals— Disadvantages of initially used "flat-top" seals—so-called because the seal mechanism consisted of two flat metallic discs, separated by a fabric washer—led to a thorough investigation of metal stampings.

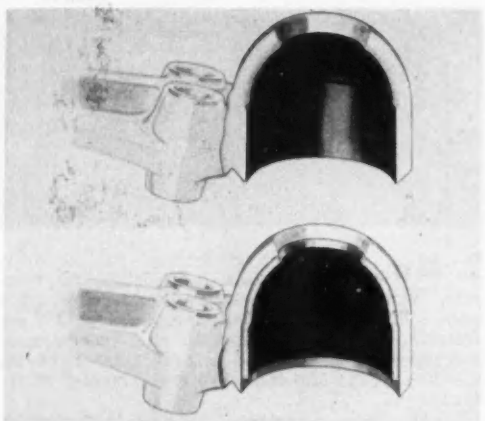
It appeared that best sealing would be provided by a light metal stamping of spherical shape. To match this shape, the socket body was also made spherical.

The resulting domed-type sockets weighed less, and the new interlocking seals were much more efficient.



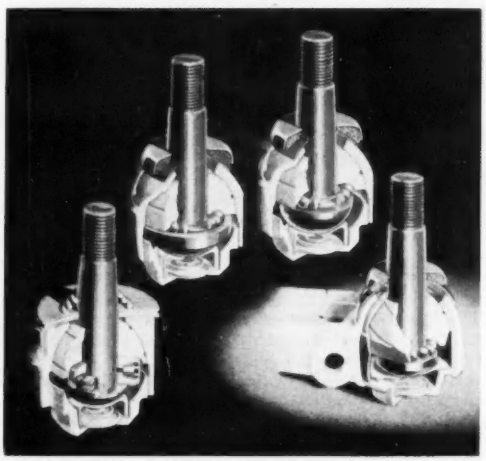
4. Lubrication— The next step was investigation of lubrication. Initial attempts included two peripheral ring-groove, and channel arrangements—both of which involved costly machining of the socket body. Economy dictated that the grooves be confined to the spherical bearing.

Three equally-spaced spiral passages were provided to wipe the loaded surfaces during suspension action and also to serve as passages for the lubricant during servicing. This system proved highly successful.



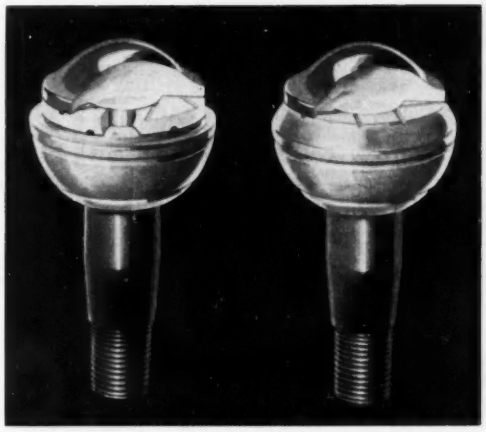
5. Scoring— Road testing experience indicated a need for increased hardness on the socket body and bearing ball faces to prevent scoring. The required surface was obtained by inserting a thin, hardened sheet metal shell.

This design side-stepped difficulties resulting from induction hardening and transferred the losses due to heat treat scrap from a costly forging to an inexpensive stamping.



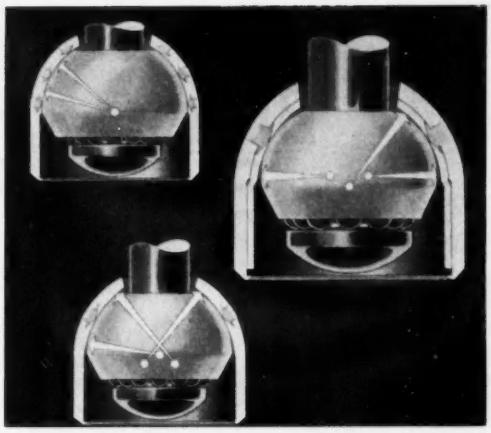
6. Studs— Endurance test work on roller bearings suggested that a more durable and compact ball joint might be obtained by using a ring of loose balls.

Early success with this type of bearing initiated a process of evolution—bringing about reductions in the size of the bearing race, the number of balls, and the stud head diameter.



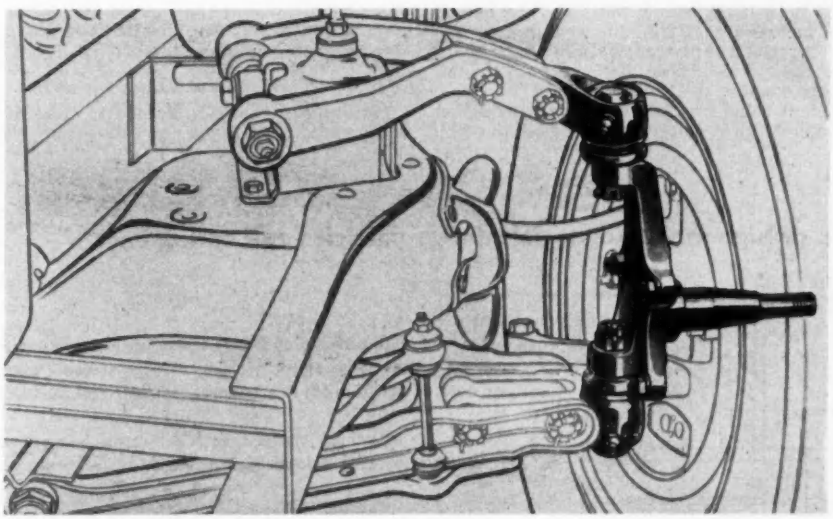
7. Clutch Material—Experiments with various clutch materials for upper socket rotational dampening produced surprising results. Little difference was found between mating surfaces of various clutch materials and mating steel surfaces.

Therefore, since this represented elimination of one part, steel mating surfaces were chosen. Extensive road testing proved this design both durable and adequate from a dampening standpoint.



8. Mating Surfaces—It was realized that manufacturing tolerances would not permit machining spherical surfaces that would mate over the entire contact area—that intentional distortion of one of these surfaces was necessary.

The socket was thus altered from a spherical to a toroidal shape. This suggested placing the toroidal shape on the bearing, and using spherical shell inserts. This design proved highly satisfactory.



9. Size—Only the problem of correct sizes for various front end loads remained to be solved.

It was originally believed that the area of the contacting surfaces between the bearing and the socket insert would be the determining size factor.

However, experiments showed that the smallest stud shank size which was adequate for shear strength—combined with a proportionate bearing and socket body—produced extremely good road test life.

$$\frac{Bhn}{E} \times 10^6 = \text{Modell}$$

$$= \text{Measure}$$

THE ability of a surface to deflect out of the way of asperities on a moving mating surface or foreign particles and spring back again seems to be important in wear resistance.

This ability to deflect elastically depends on:

1. **Elastic limit**, which is usually reported as the yield strength of engineering materials. Elastic limit is proportional to hardness.

2. **Elastic modulus**, which is the ratio of stress to strain. With low modulus metals, a small stress results in a relatively large elastic strain.

Large amounts of elastic deflection may be achieved by the selection of materials which have high strength and low modulus. This desirable combination of properties does not occur commonly in metals, but both the elastic limit and the elastic modulus of metals are controllable with limits. We thus have for the future considerable latitude in increasing the total elastic deflection of which materials are capable.

A convenient value for the total elastic deflection which is possible for a material may be obtained by dividing the Brinell hardness of a metal by its elastic modulus. This replacement of elastic limit of stress by Brinell hardness may be justified by the close relationship which exists between them as shown by the mechanical properties charts of steels.

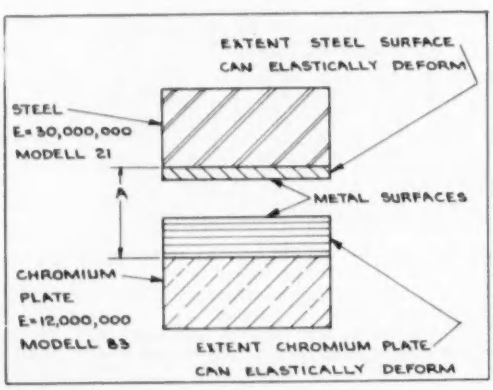
The ratio of Brinell hardness to elastic modulus, multiplied by 10^6, we will call "modell" here.

Higher modell values can be obtained by increasing hardness or decreasing elastic modulus or by doing both. Since methods of increasing hardness have been thoroughly explored, greatest gains appear in the direction of lowering the elastic modulus of materials. The introduction of interruptions to the continuity of a material and the control of crystal orientation to produce low surface modulus in the proper direction are the two most likely means of altering elastic modulus to create high modell materials of the future. Research directed toward controlling the elastic modulus of metals should be greatly accelerated.

Modells of Various Metals

Materials are listed in Table 1 in order of decreasing modell. Modell gives an indication of the depth

Surfaces of high-modell materials dodge particles and spring back



FOR particles of foreign matter smaller in diameter than A, the large elastic yielding of high-modell chromium plate should result in a low wear rate for both surfaces.

Particles coarser than A will cause the most wear on the material of lower yield strength.

The elastic cushion provided by low-modell materials helps to minimize wear only as long as the foreign particles do not exceed a critical size which is dependent upon the elastic "give" of the metal surfaces, the load, and the minimum clearance between the surfaces.

# of Wear Resistance

T. L. Oberle, Staff Metallurgist, Research Department, Caterpillar Tractor Co.

Excerpts from paper "Hardness, Elastic Modulus, and Wear of Metals" presented at the SAE Annual Meeting, Detroit, Jan. 15, 1952. This paper will be published in full in SAE Quarterly Transactions for July 1952.

of penetration that a metal can tolerate without exceeding its elastic limit. Chromium plate will recover elastically from more than 100 times the amount of deformation that will cause tin to yield plastically. Materials of high modell behave like a spring, absorbing energy and preventing loads from building up to a high value.

The low-modell materials of Table 1 have little capacity for absorbing energy elastically. These low modell materials are most suitable for use as bearings.

Because of the difficulties in measuring elastic modulus and an apparent lack of a strong need for elastic modulus data, the factors that influence the elastic modulus of metal surfaces are not clearly defined. We do know, however, that the elastic modulus of metals is influenced by melting temperature and atomic volume. The elastic modulus of low-melting metals tends to be low, and the elastic modulus of high-melting metals tends to be high. There is a tendency for elastic modulus to decrease as the atomic volume increases.

Controllable Factors in Modulus

In addition to these inherent factors which determine the general level of elastic modulus, some metals are susceptible to variations in elastic modulus that may be controlled within limits during the fabricating, casting, or heat-treating stages of manufacture. Some controllable factors that may alter the elastic modulus of metals are heat-treatment, interruptions, and anisotropy.

The aging of some age-hardenable alloys may result in a small increase in elastic modulus. Most metals and alloys, such as steels, have virtually no

Table 1—Modell values for various materials

Material	Condition	Elastic Modulus	Brinell Hardness Number	Modell
Alundum (Al_2O_3)	Bonded	14,000,000	2000	143
Chrome Plate	Bright	12,000,000	1000	83
Gray Iron	Hard	15,000,000	500	33
Tungsten Carbide	9% Cobalt	81,000,000	1800	22
Steel	Hard	29,000,000	600	21
Titanium	Hard	17,500,000	300	17
Aluminum Alloy	Hard	10,500,000	120	11
Gray Iron	As-Cast	15,000,000	150	10
Structural Steel	Soft	30,000,000	150	5
Malleable Iron	Soft	25,000,000	125	5
Wrought Iron	Soft	29,000,000	100	3.5
Chromium Metal	As-Cast	36,000,000	125	3.5
Copper	Soft	16,000,000	40	2.5
Silver	Pure	11,000,000	25	2.3
Aluminum	Pure	10,000,000	20	2.0
Lead	Pure	2,000,000	4	2.0
Tin	Pure	6,000,000	4	0.7

Table 2—Elastic properties of steel, malleable iron, and gray iron

Metal	Microstructure	Graphite Volume, %	E × 10⁻⁶	Brinell	Modell
Steel	Pearlite	0	29	200	6.9
Malleable Iron	Pearlite	10	26	200	7.7
Gray Iron	Pearlite	10	12	200	16.7

change made in their elastic modulus by heat-treatment of any kind.

Interruptions to metal continuity may take the form of cracks, gas cavities, or voids of any kind. The graphite present in gray iron is included in this classification because its low modulus apparently permits it to behave somewhat as though the enclosure around it is empty. The elastic modulus of metals decreases in direct proportion to the volume of spherical-type voids. Elongated interruptions, such as flakes or cracks, decrease the elastic modulus of a metal in a direction transverse to the long dimension of the discontinuity.

Anisotropic single crystals exhibit different properties in one crystallographic direction than another. The elastic modulus of a single crystal of iron is 19,200,000 psi in a direction parallel to any one of the three major axes. As the direction of load is tilted away from these major axes, the elastic modulus increases until a maximum value of 41,240,000 psi is obtained when the load acts along the space diagonal between the three axes. Polycrystalline metals, under certain conditions, will give up their random crystalline arrangement and assume a preferred orientation. Such preferred orientations, as developed during cold working or plating operations, have not as yet been exploited for maximum control of the elastic modulus of metal surfaces.

Flake Shape Affects Wear

The success of gray iron in resisting engine wear is attributed by some engineers to the lubricating qualities of the graphite present. Yet, malleable iron containing the same amount of graphite as gray iron cannot be substituted successfully for gray iron in many engine parts. Table 2 illustrates some real differences in elastic properties between malleable iron and gray iron that exists as a result of the shape or form of the graphite particle independently of the graphite volume.

The difference in modell values alone is sufficient to account for superior running qualities of gray iron. Gray irons containing finely dispersed dendritic graphite may have elastic modulus values as high as malleable iron, so that more knowledge than just that the iron was cast gray is necessary to judge the suitability of the material for frictional applications.

Table 3—Wear of gray irons from Lane

Alloy	Rockwell B Reading	Flake Graphite, mg weight loss	Dendritic (Finely Dispersed) Graphite, mg weight loss
A	89	14.7	26.8
B	89	16.4	26.1
E	89	16.0	25.3
H	89	14.0	29.5

P. S. Lane and others have indicated that the shape of the graphite flakes in gray iron is influential in resisting wear or improving running qualities. Preferred structure is randomly orientated graphite corresponding to AFA Type A designation. These flakes cause a greater reduction in elastic modulus than other forms of graphite. Data obtained by Lane[1] on the wear loss in milligrams for gray irons of 89 R_B with different shaped graphite particles, are shown in Table 3.

While Lane gave no elastic modulus data for these irons, the flake graphite iron has substantially lower elastic modulus than the dendritic graphite iron, and therefore higher modell. This difference in modell for irons of the same hardness indicates that variations in elastic modulus do influence wear. A. B. Shuck[2] reported elastic modulus, hardness, and wear on a number of gray irons cast in ¼ to 1½ in. square bars to produce graphite from coarse Type A to fine eutectiform dispersion. Curves plotted from Shuck's data on seven unalloyed gray irons show:

1. Wear increases as hardness increases.
2. Wear decreases as elastic modulus decreases.
3. Wear decreases as modell increases.

Wear increasing as hardness increases is contrary to expectation. This reversal of the usual trend is the result of the sharply increasing modulus that occurs simultaneously with the hardness increase. For most materials, the elastic modulus is unchanged during hardening and its influence is not felt. Shuck's data on alloyed irons confirm these trends. It is unfortunate that most other papers on metal wear do not give sufficient data to permit an analysis of the influence of elasticity upon wear. Data from various sources indicate that for wear applications, gray iron should be cast with coarse graphite flakes and hardened by heat-treatment to produce maximum modell. This is preferable to obtaining high hardness in an as-cast, high-strength iron with resultant high elastic modulus.

Alundum Liners Wear Well

Outstanding wear results have been observed with the use of some materials normally considered abrasive. Tests conducted at the Caterpillar Research Laboratory have shown alundum cylinder liners to possess excellent wear resistance. In addition to freedom from liner wear, the wear rate of piston rings is greatly reduced. With economical methods of manufacture of alundum wearing surfaces this material may become as commonplace for engine

[1] See ASME Transactions, Vol. 62, No. 2, Section 1 (February), 1940, pp. 95-110: "Wear of Diesel-Engine Cylinders and Rings," by P. S. Lane.

[2] See Transactions of American Foundrymen's Association, Vol. 56, 1948, pp. 166-193: "Laboratory Evaluation of Some Automotive Cast Irons," by A. B. Shuck.

and tractor parts as semi-precious jewel mountings have for timepieces.

Powder metallurgy techniques permit combining of extremely hard oxides, carbides, and nitrides with a suitable binder to yield an aggregate of low elastic modulus. Current work on ceramic-metallic materials is centered around high-temperature applications in jet engines. A bright future for ceramic-metallic materials exists in the field of wear applications for such parts as face seals and valve guides.

Machinability Considerations

One requirement of a cutting tool is to produce sufficient load to exceed the elastic limit of the workpiece without endangering the tool. This can be accomplished by a high-modulus, high-Brinell material. The 22 value for modell of tungsten carbide shown in Table 1, has somewhat different significance than a high modell value of low-modulus materials. Because usual loads on tungsten carbide tools are much smaller than the material can stand, only a small part of the possible elastic deformation is used. The unused portion of the elastic region of the stress-strain curve represents reserve capacity of the tool which insures long cutting life.

Gray iron at Bhn 300, steel at Bhn 600, and tungsten carbide at Bhn 1800 all have a modell value of about 22. Since the stress upon gray iron at its elastic limit is less than the load that steel or tungsten carbide can carry, gray iron can be deformed (machined) by tool steel or tungsten carbide with little damage to the tool. This indicates a need for similar moduli for two metals running against each other when low wear is desired for both materials.

As a general rule, the difficulties of machining increase with the hardness of the work. However, if the hardness is to be kept low for easy machining, the modell value or wear resistance may be increased by lowering the elastic modulus of the material. Lowering elastic modulus improves resistance to wear and at the same time may improve machinability. High-modell materials, if gray iron is any criterion, machine more readily than low-modell materials of the same hardness. A considerable economic advantage will result from developing wear-resistant materials of low hardness. For gray iron, this will involve some degree of control of graphite flake size and orientation. Maximum wear resistance will result if some of the graphite flakes near the surface can be aligned parallel to the loaded surface.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Dept. Price: 25¢ to members, 50¢ to non-members.)

Excerpts from Discussion

R. H. Bancroft, Perfect Circle Corp.—The relative wear of metals, although of the utmost importance to engineers, has been in a state of confusing disorder for more than fifty years. Prior to that time it was worse, but, oddly enough, due to a prevailing use of low-modulus materials in the old days, the practical effects then were fairly good.

It is not for lack of experiment, investigation, and data that this disorder has continued; but rather to a misinterpretation of the causes of the effects noted. Few technical gatherings of importance have been without their wear symposia. Instead of leading to a better understanding of the real mechanism of wear, the empirical mass of data has resulted in a number of unrelated and even opposed general statements, some true, some half-true, some perhaps not true at all; such as:

1. Good wear is possible only between dissimilar materials.

2. Graphite is a good lubricant; so is gray iron.

3. Extra smooth surfaces provide the best wear.

4. Finely roughed surfaces provide the best wear.

5. Good wear is best affected by efficient heat-extraction.

6. Wear is best with coarse pearlitic microstructure.

7. Wear is best with fine martensitic microstructure.

8. Ferritic microstructures are inimicable to proper wear.

9. Nodular graphite in gray iron makes for excellent wear.

10. Coarse flake-graphite promotes the best wear.

11. Flakes, dendrites, or nodules—there is no perceptible difference.

12. Low-carbon irons are good for wear.

13. High-carbon irons are definitely indicated.

14. Hardness promotes proper wear.

15. Soft iron promotes proper wear.

We have all belonged at one time or another to several of these schools of thought. Certainly, whenever two or three of us are gathered together in the name of "wear," an immediate debate is precipitated.

And then, out of the darkness of these depths there came Oberle and brought us to light. Perhaps 11 of the 15 generalities just enumerated, including at least three pairs of apparently directly opposed statements, become true and lucid when viewed in the light of his suggested modell index.

To me, the simple fact that wear is in no way dissimilar to the problem of machining of metals is not even debatable. Further, when two opposed surfaces engage in sliding friction and two bumps of surface imperfections collide, something has to give or else disintegrate. So simply true is this as not to have been obvious before. In confirmation, at the SAE Round Table on "New Aspects of Wear," held at the SAE Summer Meeting, French Lick, Ind., June 7, 1951, C. D. Strang, Jr., of M.I.T. pointed out that not only had the abraded particles in wear tests been observed to be extremely small (about 50 atom diameters and hence almost unnoticed) but that their stresses created unit pressures exceeding the elastic limit of the materials, which promptly wore out. So much for the damage by the par-

ticles which were originally bumps that were unable to "dodge," by reason of insufficient elasticity.

So, how to enhance the elasticity now becomes important, because how to increase hardness has been fairly well exploited already. The paper points out that perforated steel, with its artificially lowered effective modulus of elasticity, may be directly likened to the effects of the fissures of the graphite in cast iron. The further effect of randomness and orientation and shape of such fissures is no less interesting.

Because we know, or ought to know, especially if we work with piston rings, that, as we proceed from soft, flake-graphitic gray iron through the dendritic iron, through nodular carbon malleable, and finally to steel, we have always observed a steadily increasing tendency to scuff and to wear. Now it becomes very obvious that we were at the same time correspondingly descending in modell number, as this wear picture increased.

Now, this obnoxious circumstance prevented the active use of both steel and malleable rings for a long time, until finally we covered each up with chromium plate and then obtained the most satisfactory wear to date. But here again, the chromium-plate modell number went away up to a figure three times as high as the previous best iron material.

I think we will probably have to admit that the introduction of a suggested index like Oberle's modell number is not a little step but a great big furlong stride in taking the evaluation of wear out of the realm of cloudy empiricism into that of a science with a working formula.

It is interesting to ponder why this has not been understood before and also why it is still occasionally unacceptable to the lay mind. I have had some big arguments about it. People either see it readily, or not at all. Perhaps one reason is because of the difficulty of seeing how one index can interpret and serve as the function of three other varying factors. The modell number cleverly represents the compound assessment of three properties of a material, namely:

(1) The hardness (which, as it increases, improves wear resistance).

(2) The amount of stress to give maximum deformation within the elastic limit, and the less stress required to do it, the better the wear.

(3) The amount of such strain or deformation obtainable within elasticity (or complete rebound), and the more the better.

Another reason for heretofore difficulty in seeing around these corners is the sloppiness frequently attending the visualization of the term "modulus of elasticity," which is in itself but an index or ratio of stress to strain. Too often has the term "low modulus" been associated with almost anything but what it means (and that is high elasticity). I guess we have here the semantic impact of the word "low," which is generally an anathema to engineers, who usually like to think they are striving always for something "high."

But anyhow, with these things set straight (seriously), the future of the wear problem should now be much brighter for this work; which, moreover, opens up the probability that research in anisotropic crystals, x-ray diffraction studies, crystal orientation, and the like may bring about eventual improvements in our understanding of both the mechanism and metallurgy of wear.

T. O. Kuivinen, Cooper-Bessemer Corp.—In Table 1 Oberle shows gray iron, as cast, having a modulus of elasticity of 15,000,000 psi and a Brinell hardness of 150. The latter seems low when comparison is made with other published results. Iron having 15,000,000 psi modulus should give a tensile strength of about 30,000 psi and an average Brinell hardness of 187 in a range of 156 to 220.

Before any conclusion is made that the new function "modell" is any criterion of wear characteristics of engineering materials, considerably more wear data should be reviewed and correlated with this philosophy. The paper presents no comparisons covering the many types of materials being used for piston rings and cylinder liners. The author's "idealistic" approach to determining suitability of materials for wear resistance, particularly for internal-combustion engines, cannot always be borne out in practice, as too many individual factors affect each case.

J. T. MacKenzie, American Cast Iron Pipe Co.—Have you considered using the square of the Brinell hardness number instead of the first power in your modell expression? If you used the square, the expression would resemble a formula the pipe industry uses in estimating the toughness of cast-iron pipe. If:

$$\text{Bhn} \propto S$$

$$E = \frac{S}{\varepsilon}$$

then the formula is:

$$R = \frac{S^2}{2E} = \frac{S\varepsilon}{2}$$

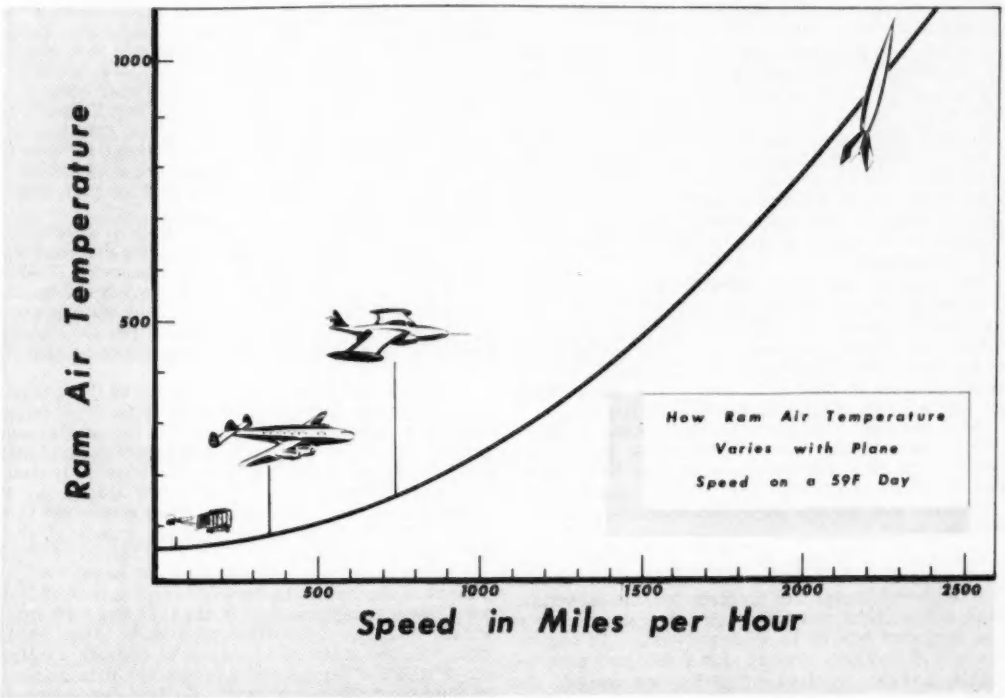
where:

S = Yield strength
E = Modulus of elasticity
ε = Elongation at the yield point
R = Resilience
$\frac{S\varepsilon}{2}$ = Area under the stress-strain curve for cast iron

Oberle: Yes, we have considered using the square of the Brinell hardness in the modell expression. If we use the second power, modell becomes very similar to the modulus of resilience of a material, which spring designers recognize as a measure of the total amount of energy that may be stored in a spring. Modell with Brinell hardness to the second power may be an accurate measure of the total energy which may be stored or absorbed elastically by a metal surface. The wear data available are not sufficiently accurate to permit choosing between the first power and the second power of Brinell hardness in the modell expression, so the simpler first power of hardness has been used in this paper. In 1951 I mentioned the possibility of the modulus of resilience being a suitable measure of wear resistance.

J. T. Richards, Beryllium Corp.—The case of beryllium-copper provides further evidence in support of the author's conclusions, since this alloy in the fully heat-treated condition offers a relatively low modulus (18,000,000–19,000,000 psi) and high hardness (370–440 Brinell). Instances have been reported where beryllium-copper has been found to wear various types of steel of higher hardness in sliding contact. Possible abrasive action by beryllium oxide was probably not a factor, although the surface may have been covered with thin films of either cuprous or cupric oxide.

In considering means of controlling modulus, it is of interest to note that the tension modulus in beryllium-copper can be varied over a range from 14,000,000 to 26,000,000 psi by means of suitable combinations of cold-work, solution treating, and precipitation hardening. This increase amounts to 86% and, although this value is considerably lower than variations known to exist in metallic single crystals, it is exceedingly high for a commercial alloy.



Higher plane speeds are raising ambient air temperature so that . . .

The Heat's on Aero Engineers

Advent of supersonic aircraft is boosting equipment operating temperatures. It's forcing designers to hunt for a new breed of heat-resistant materials, SAE technical committees reveal.

HEAT is the growing bugaboo that's getting aeronautical engineers in a sweat. Operating temperatures of airplanes, particularly military craft, and their equipment are rising to the point where today's materials and designs won't hold up in tomorrow's planes. It's got aeronautical engineers and equipment designers scrambling for an out, as current activities of SAE aeronautical technical activities show.

Yesterday, aeronautical engineers worked at protecting the pilot and airplane against cold in flight. Today, engineering emphasis has taken an about face . . . warding off the heat in supersonic airplanes looms as a top problem.

The faster modern military craft fly, the hotter things get. The ram effect heats up the air normally used for cooling and skin friction begins to make itself felt. Engineers on SAE committees are beginning to look for materials to buck high temperatures, and it looks like a long road ahead before materials catch up with requirements.

High speed is the source of the heat evil. At flying speeds up to 500 and 600 mph, the air taken into engine compartments and other parts of the plane is sufficiently low in temperature to cool working parts. The faster an airplane flies, the more it compresses and heats up the air ahead of it. Above Mach 1, the speed of sound, the ram air temperature rises rapidly. (See chart above.) At Mach 1, it may be 160 F, 465 F at Mach 2, and 995 F at Mach 3.

So instead of cooling airplane components and

equipment like ignition and hydraulic equipment, the air heats them up.

It looks as if airplanes may soon be developed that fly at speeds of 1500 and 2000 mph. That means equipment will have to operate at temperatures of over 500 F.

Present materials—like electrical insulation and hydraulic fluids—just can't stand that gaff. They deteriorate quickly under such conditions. If they were used in coming supersonic airplanes, entire systems might have to be replaced before every flight to prevent failures while in the air. Obviously that's not feasible.

Refrigeration has been suggested as an out. But in most cases it won't be practical, point out aeronautical engineers, except perhaps for packaged equipment. That's because supersonic planes have to be smaller, yet pack more equipment. Space on them is more critical than ever. The thin wings on fast military fighters are a case in point.

So if you can't cool down the equipment, build it of materials that can live with the heat, reason aircraft designers. But that's easier said than done. Conventional materials like rubber, leather for packings, and plastic insulations are not in this league.

Cold Cuts Some Ice

What complicates the problem for the materials man is that heat resistance isn't the only property the material has to be endowed with. It has to operate at temperatures of -100 F too, and demonstrate certain required properties at 500 F. So now engineers are talking about environment-free materials.

More than ever before the pressure is on materials men. Design engineers say their hands are tied; they can't build faster aircraft until materials that stand up are made available to them. The cry is out for more materials research and development by both industry and government.

Projects and discussions in SAE committees are spotting the kinds of materials and equipment where heat can be devastating. Committee meetings are emphasizing materials shortcomings in places such as ignition equipment, hydraulic systems, electric motors and generators, wheels and brakes, and electronic equipment.

Already the SAE Ignition Research Committee is looking into some new materials for ignition cables that will withstand high temperatures. Neoprene rubber, which has been used for ignition cable with piston engines, will have to give way to hardier materials.

It was recently reported at a Committee meeting that ignition cable temperatures may eventually run as high as 700 to 900 F. Both Teflon and silicone are being researched for high temperature work. Silicone cable looks as if it'll do a job up to 400 F, Teflon up to 500 F.

Members of the SAE Aircraft Hydraulic and Pneumatic Equipment Committee have been alert to the heat problem for years. They say that the hydraulic system with its long lines normally is cooled by radiation; but hot ram air and airplane surfaces at supersonic speeds will heat, rather than cool hydraulic equipment.

It looks as if present hydraulic fluids, seals, and packings are good for continuous operation up to about 180 F. As temperatures rise above this, packing life, for example, goes down. This also seems to be true of rubber O-ring seals and rubber hose.

Teflon seals are being considered. But Teflon has a drawback . . . in that it is not as resilient as present materials and takes a permanent set under stress. Reports to the Committee note that metallic hose and seals are being investigated for high temperature applications.

At temperatures above 200 to 250 F, hydraulic fluids start to decompose and cause troubles due to gum and tar accumulations. Nonflammable fluids, especially those with a water base, may break down at these high temperatures so that the water separates from the other compounds. Then too, vapor lock due to boiling of fluid constituents is also a likelihood.

Silicates seem to hold some promise as high-temperature fluids. At this stage they're far from fully developed. One type silicate fluid tested showed several desirable characteristics; but during the test, the system filter clogged. It turned out that the clogging was due, among other things, to a softening of the glue in the filter paper by the fluid. And this points up another aspect of the new materials problem.

Finding materials that will stand up in each component of the hydraulic system is only a part of the job. What complicates it is that all the new materials must be compatible with each other. For example, the fluid must not only operate in the -65 F to 600 F temperature range, but it must also be kind to packings and seals. So fluid development must go along hand in hand with packing and seal research.

The high temperature dilemma has been working its way into electrical components too. Discussions in the SAE Aeronautical Electrical Equipment Committee show that motors and generators succumb to heat. Insulating compounds in these components soon lose their dielectric properties if subjected to excessive heat for any length of time.

Heat Penalty Already

The situation already is serious enough so that generators are being derated for higher altitudes. (Part of this rating reduction stems from heat.) It looks as if similar steps will have to be taken with continuous-duty motors.

The SAE Aircraft Instrument Committee reports that what's happening to insulating materials in electrical units is going on in instruments. New compounds will have to be created so that instruments can live with heat. The problem here is not so acute since most instruments are located in a controlled temperature area. But this should imply no satisfaction; the area is temperature controlled, in certain cases, only because the equipment requires it.

You wouldn't normally suspect wheels and brakes of suffering any penalty from the high-speed, high-heat problem. Yet the SAE Aircraft Wheels, Brakes, and Axles Committee is in the same boat as the ignition, hydraulic, and electrical groups. Members of this Committee note that as aircraft are built for higher speeds, they have to be designed with thinner

wings. The thinner the wing, the less space there is for stowing the landing gear, and the smaller wheels and brakes have to be.

On top of this, these "hot" airplanes land at high speeds, so that brakes have a greater stopping job to do. Altogether it means more and more heat to be soaked up by less brake lining and smaller discs.

Designs Shrink, Heat Swells

As planes get faster, more and more electronic equipment is being poured into them for navigation, communications, and armament systems. This equipment in itself generates considerable heat. But since space is at a premium, electronic equipment is being miniaturized. It may occupy less space, but still handles the same power load. So the same heat gets concentrated in small packages. And that can prove detrimental to delicate electronic components.

The SAE Aircraft Air Conditioning Committee is readying itself to cope with this situation. It has asked that its scope be extended to encompass this problem. The Committee feels it can be helpful in developing specifications for air conditioning equipment that will cool electronic and radio compartments.

Although the problems in each of the SAE committees differ as regards heat resistance, members of these groups agree on one point: Research and development on new materials and designs has to be launched now, if they are to be available in the next few years when Mach 2 and Mach 3 airplanes will be off the drawing boards. Starting such a program now will save much time later, and will help produce better military planes and equipment.

Bolt Loading . . .

. . . can be made uniform by new technique and thus reduce failures caused by erratic effects of torque wrench.

BASED ON PAPER BY **Alfred C. Gunsaulus** Goodyear Aircraft Corp.

FAILURES in highly stressed, light weight airplane structures can result from loose bolts or from bolts tightened too zealously by mechanics armed with torque wrenches which are thought to be the best tool for uniform loading. Actually, there is no guarantee whatever of uniform loading if the threaded fastening is tightened dry. The pound load may vary anywhere from 40,000 to 80,000.

By using electric strain gages to provide the information needed to calculate bolt stress and then manipulating the bolt, using a different combination of friction reducing materials with each manipulation, conditions were found which produced and maintained the least variation in the load on the bolt. Out of this evolved what is now known as the Lubtork process which is simply a bolt tightening process in which all the friction surfaces of a bolted assembly are coated with a 50-50 mixture by volume of graphite and petrolatum.

Certain precautions should be taken to get satisfactory results with this process. Do not use standard torque tables for bolt and nut fastenings or the bolt will be seriously overloaded, due to the greater efficiency and consistency of the properly lubricated assembly. Use of anything but the graphite-petrolatum combination will be found to be unsatisfactory. All other greases, oils, and antifriction coatings which were tried, proved to be much lower in effectiveness and much less consistent. Again, if consistent results are to be obtained, the compound must be applied before each tightening. (Paper, "Lowering the Ignorance Factors in Airplane Wheel and Brake Development," was presented at SAE Canadian Section, Toronto, Jan. 22, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

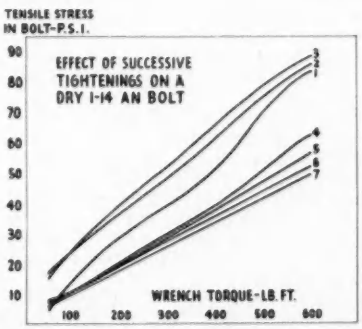
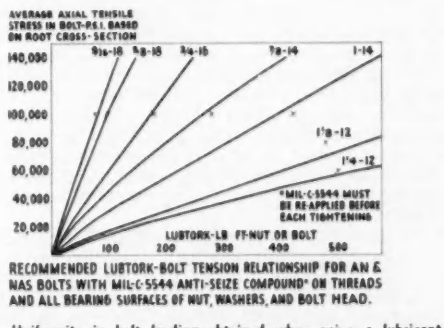


Fig. 1—Variation in pound loading of a bolt when tightening the bolt dry with a torque wrench



RECOMMENDED LUBTORK-BOLT TENSION RELATIONSHIP FOR AN & NAS BOLTS WITH MIL-C-5544 ANTI-SEIZE COMPOUND* ON THREADS AND ALL BEARING SURFACES OF NUT, WASHERS, AND BOLT HEAD.

Fig. 2—Uniformity in bolt loading obtained when using a lubricant composed of a 50-50 mixture by volume of graphite and petrolatum in conjunction with a torque wrench

Turbine

In his complete paper, Mr. Brandt makes this plea:

"Give the aircraft industry a voice in this matter of determining what type of fuel will be used with what type of engine. This vital member of the team of first-line defense has been kept in the position of a frustrated bloodhound chasing Eliza much too long. It certainly is a waste of time and effort to design an engine for a specific fuel, install it on an airplane, then suddenly find the fuel system will not handle the fuel required.

"The airframe industry is the coordinator of all the articles and devices incorporated in the airplane. As such, it should have a vote on the fuel question."

FUEL SYSTEMS for turbine-engine aircraft present a host of design problems. Among them are:

- Prevention of boil-away during climb.
- Determination of optimum plumbing diameters.
- Provision for removing fuel contaminants.
- Addition of instrumentation.

Boil-Away

Years of experience with gasoline have resulted in the establishment of formulas to predict these losses. If the formulas are used with caution, the amount of boil-away can be determined within close tolerances. These formulas also indicate that rate of climb, at least with present aircraft, is not an important factor. The magnitude of the losses is strictly a pressure/temperature relationship.

On the other hand, rate of climb is extremely important with JP-3 fuel. Investigations show that tremendous losses occur due to foaming and slugging, although actual normal boiling loss would be slightly less than gasoline. This fuel has the peculiar ability to foam violently when boiling. As the foam escapes from the liquid surfaces, its velocity is sufficient to entrain liquid fuel and slug it out the vents. Rate of climb influences foam escapement velocity and hence total loss. The cause or cure of foaming is not known at this time. Therefore, an attempted mathematical solution is laborious and difficult and will yield only qualitative results.

To illustrate the magnitude of the losses, Convair conducted a mathematical investigation on a mythical airplane capable of climbing 20,000 fpm to a ceiling of 50,000 ft. In this instance if the fuel was 110 F at takeoff, 103% of the fuel was lost at 50,000 ft, indicating the airplane would run out of gas before it reached ceiling.

Certain tests conducted by other groups tend to bear out large loss expectancies. As high as 75% loss has been reported. From experience to date, it appears that if the rate of climb in the tank is kept below approximately 1000 fpm, slugging losses can be minimized when JP-3 type fuels or others that have a tendency to form are utilized.

After going to such great lengths to put the required amount of fuel in the airplane, it is obvious that the designer cannot idly stand by while most of it slugs out the tank vents to pollute the atmosphere. The several methods of approach for boil-away alleviation are:

1. Use of low-vapor-pressure fuel.
2. Ground pre-conditioning of the fuel.
3. Pre-conditioning of the fuel in the aircraft before flight.
4. Airplane tank pressurization.
5. Vapor distillation and recovery during flight.

Tank pressurization is the accepted method of preventing vapor losses at the present time. This is generally accomplished by continuous charging of the tank from an external pressure source shortly before or just after the airplane is airborne. Or it may be done by isolating the tank from ambient atmosphere above certain altitudes thus providing internal pressure by means of fuel ebullition.

Tank pressurization has the several disadvantages. For example, the degree of pressurization required makes it difficult to provide effective passive defense. In most instances it is necessary to provide combat dumping to permit bullet-sealing tanks to operate efficiently when subjected to gunfire. (Such sudden release of pressure may cause severe boiling and aforementioned slugging.)

Besides aircraft structural weight is generally increased because of the necessity for providing additional "beef-up" for tank support. Design and installation of purging protection is made much more complicated by pressurization. And possible tank blow-out is a hazard added to an already hazardous system.

Pressurization may not stop boiling in complicated systems wherein fuel is transferred from auxiliary to main tanks and is subjected to depressurization through the transfer equipment.

Engines Complicate Fuel System Design

C. Stewart Brandt, Consolidated Vultee Aircraft Corp.

Excerpts from paper "General Design Aspects of Turboprop and Turbojet Aircraft Fuel Systems" was presented at the SAE National Aeronautic Meeting, Los Angeles, Oct. 4, 1951.

Plumbing Diameters

The prime Military requirement for power means increased fuel consumption, which in turn indicates the need for higher and higher flow rates. In certain turbojet, afterburner-equipped aircraft flow rates up to 90 gpm are of common occurrence. (Translated into more significant figures, this means that the distribution system must be designed to permit transportation of over 16 tons of fuel to the engine every hour.)

Data obtained from tests, investigations, and experience over the years have enabled the engineer to determine the plumbing diameters required for reciprocating engined airplanes by choosing the tube size from a maximum line velocity limitation standpoint. The value commonly used for this maximum limit is 130 fpm—that is, the I.D. of the tube or hose must be large enough to prevent the maximum internal flow from exceeding a velocity of 130 fpm. It has been proved that this limiting value results in an optimum performance distribution system on a weight/pressure requirement basis.

If this same rule is applied to turbine-engine 90-gpm-demand installations, we would find that the smallest permissible tube or hose would be approximately 4 in. in diameter. Space limitations are such that it would be impractical if not impossible to install plumbing of this size in a fighter-type airplane and extremely difficult to put in a bomber.

Obviously, we need a new design philosophy for determination of plumbing diameters to achieve optimum performance. Unfortunately experience to date with turbojet and turboprop aircraft is not sufficient to crank out the magic maximum flow velocity limitation number; it is necessary to carefully analyze the installation by taking into account, weight, velocity, working pressures, maximum anticipated surge, type of fuel, pumping equipment availability, and a host of other factors to come out with the correct size tubing.

Although one of the military services is contemplating specifying maximum allowable working pressures, this may not aid in obtaining the desired optimum performance number inasmuch as the limitation is to be imposed primarily because of certain fuel system components.

Cleanliness

Providing for clean fuel is not as easy as it sounds. Most turbine engines appear to be very susceptible to foreign material, particularly in the regulator or fuel-flow-control units. To insure relatively undiluted supplies, the designer must install elaborate filtering equipment that will remove particles on the order of 10 microns (0.001 mm) in diameter. These filters do such an excellent job of cleaning the fuel that they rapidly plug themselves up and cause all sorts of trouble. For example, it has been found that:

1. Ice crystals formed by entrained water in the fuel will plug the filter.
2. Insoluble waxes dropped out of certain types of fuels during low-temperature operation will plug the filter and,
3. One part of sand in a million can plug a filter in approximately 30 hours of operation, at present flow rates.

Ice plugging is a serious problem, and many weird and wonderful ways are being developed to combat the situation. Heated filters, hot fuel through the filters, alcohol de-icing, and other systems have been proposed and used.

Alcohol systems do not appear to be the best means to achieve the desired results for they offer storage, plumbing, and pumping problems in themselves, and means must be provided to keep the alcohol dehydrated.

Heated filters, especially with the high flow rates now being encountered, require too much power. In an effort to reduce these requirements, dual, alternate-flow, automatic, heated de-icing filters have been proposed. But weight and space limitations on most aircraft make an installation of this nature impractical.

Many of the newer turbojet engines employ fuel as an oil-cooling medium. It would seem logical to install the filter on this side of the system to

insure ice-free operation, provided that the engine-driven fuel pumps will accept normally contaminated fuel.

Wax clogging has not been too important to date, primarily because heavy fuels which are prone to waxing are not generally employed.

The only practical solution to filter plugging due to sand is to service the aircraft with sand-free fuel.

From the fuel-system designer's viewpoint, the need for micronic filtration should be thoroughly reviewed and concentrated efforts be expended to increase engine dirt tolerance to the maximum. There are many industrial control systems today operating under just as severe conditions, that require only a limited degree of micronic filtration. It would certainly be feasible to apply some of these lessons to the airplane.

Controls

We are now installing all manner of flow, supply distribution, and c.g. control devices that function to relieve the crew of fuel system management except in emergency. The frantic search for volume storage space has, in the main, brought about these systems. However, in some instances, it was done initially to relieve the pilot. Unfortunately, it is still necessary to provide some sort of override control mechanism that permits selection of various operating combinations to minimize combat damage effects. On multiengined aircraft this usually leads to quite a complicated fuel system control arrangement.

It is also customary, on aircraft employing flight engineers, to provide that member of the crew with a complete fuel system control panel. In most instances the panel is in "Road Map" form with the maximum of visual flow pattern indication and a minimum amount of printed instructive matter. (Such schemes have generally proved to be very effective).

As the airplane improves in performance we find it requires more and more protection for its fuel system. For example, a mythical airplane takes off from a northern base, flies at high altitude, and sets down on a hot, desert airfield. At engine shutdown, the pilot carefully closes all the fuel system control valves isolating lines full of fuel from the tank and engine. The cold fuel in the isolated lines gradually warms up and expands. If the system happened to be strong enough to withstand the expansion load, we would find, assuming at 120 F temperature rise, a pressure build-up of approximately 7000 psi. Obviously, no designer in his right mind will attempt to install equipment capable of withstanding such rises. Therefore, thermal relief must be provided further complicating the already far-from-simple system.

Once the fuel system has been laid out and developed to satisfy the basic requirement of design and the resultant secondary requirements of operation, it is then desirable to furnish instrumentation to indicate satisfactory operation and to provide certain important measurements to insure completion of the mission.

Fuel quantity remaining and rate of consumption are the most important parameters. Temperature, pressure, and water entrainment are nice to provide if space and weight permit but not absolutely necessary.

The latest quantity-measuring gage is a complicated electronic gadget which in effect is a condenser tied into a null-balancing system. The condenser, when installed in the reservoir measures the dielectric constant difference between the column of air and fuel between the plates and through the signal transmission equipment passes this information on to an indicating dial in the cockpit. While admittedly these units come the closest towards measuring what we would like to determine, they still cannot be considered as completely satisfactory because:

1. They are attempting to measure mass by means of a characteristic of the fuel other than its mass which does not vary strictly in the same ratios or proportions.

2. They do not take into account density and temperature changes.

3. They are attempting to measure and report on a fuel characteristic for which there is no acceptable standard measuring stick to date.

4. There is a complete lack of information on the changes that may take place in the fuel during aircraft operation that could upset the calibrations.

In the main, the present gages are predicated upon the dielectric characteristics obtained by a vast sampling procedure. The laws of probability, based on the number of samples analyzed, will show that supposedly the chances of obtaining fuel with either dielectric extreme are remote. However, what is not known is whether that extreme sample came from a production batch of 1000, 10,000, or 1,000,000 gal of fuel. When dealing with petroleum products in an airplane, the number of gallons in the batch with the extreme must be known for it can mean the possible underloading of the airplane in relation to engine demand or overloading in relation to performance.

Many aircraft must operate on two different fuels or mixtures thereof. Imagine trying to measure the quantity of fuel for these aircraft! In an attempt to accomplish this, we are now installing fuel-gage compensators which, in effect, try to determine the new dielectric constant and signal this information to the gage for proper correction.

On the whole, attempting to measure fuel consumption with presently available instruments leaves much to be desired. The units are generally volume-measuring devices, calibrated in pounds, which even if carefully matched (indicator to transmitter) will not give a true pounds used figure at the calibrated temperature. We are badly in need of a mass-measuring device that can be installed and successfully operated in an airplane.

Serious consideration must be given to the fuel measurement problem for in dealing with the large-gallonage airplane today and the future, the difference of 3-5% in measured quantity from actual, may be the difference in failure or success of a given mission. Perhaps an entirely new approach is needed to achieve the desired results.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Where to Store Fleet Vehicles . . .

• In Garages?

• In Sheds?

• Outdoors?

Henry Jennings, Technical Editor, Fleet Owner

Report on Round Table on Garages versus Sheds versus Open Air, held at SAE Summer Meeting, Atlantic City, June 3, 1952, under auspices of SAE Transportation & Maintenance Activity Committee.

NO fleet operator wants to store vehicles outside or is even indifferent about storing them outside. It is purely a question of money. The only decision facing the operator is when and under what conditions is it cheaper to invest large gobs of money in buildings.

Cost of construction has driven the operators to open air storage. One public utility operator has found that a building to house his fleet would cost in the neighborhood of $30 per month per vehicle, and this is too much. Another operator in the same business has found that by sticking to standard size buildings he can do it for $15 to $18 per month per vehicle in the 60-ft width, 5400-sq ft type of building. This is for small to medium vehicles. Larger vehicles of course aggravate the problem.

All forms of eating your cake and having it too, have been tried. Range of compromise runs from surfaced parking lots to roofs, walls on the windward sides, and fences. Add to this list such mechanical devices as immersion heaters turned on by a watchman or controlled by electric clocks, oil fired furnaces with quick attaching couplings to the cooling system, and you have some idea of the ingenuity that has gone into licking the housing problem.

Omitting the cost of garaging from the budget can easily leave the operator in the grease rather than the gravy. Vehicles have extravagant tastes and like the luxury of the enclosure. Dew, a form of precipitation familiar to ballad writers, is worse than rain on finishes and ease of starting. Drivers have an aversion to shoveling snow off the vehicle before starting the daily rounds.

Near the seashore the problem is more severe because corrosion of sheet metal is accelerated. The South has its own particular handicap in the form of fungus. According to an operator from Montreal, in temperatures of - 10 F. vehicles just did not start after all night storage in the open without the application of some heat.

Added to the loss of cargo carrying time when vehicles do not start promptly is the additional time spent by the driver in a coffee stop as soon as he pulls clear of the yard. During this period the en-

An unseen fleet operator is holding forth on the pros and cons of ways to store commercial vehicles . . . garages, sheds, or out in the open. He's got the full attention of Round Table Secretary Henry Jennings (left), of Fleet Owner, and Round Table Leader Emil Gohn, of Atlantic Refining

gine is left running to warm up the cab. The cold starts do not do the engine any good and in the summer it's dust that speeds up wear.

One estimate of increased rate of finish wear was from 24 months to 16 months on tank trucks. Also noted was a tendency of decalcomanias to come loose.

Even with outdoor storage, some type of building is usually necessary in a scattered fleet, unless the operator is prepared to ferry the vehicles to a remote location for preventive maintenance services and washing. Such an enclosure is not necessary, of course, if the storage yard is near an already existing shop. If not, the building must also include a stockroom.

Some dopes for waterproofing the ignition came in for favorable comment; but it appears that these materials are effective only when the ignition system is clean. Thus, the cost of periodic engine cleaning and re-application of the waterproofing will be increased in proportion to frequency.

Coming to grips with the specific problem in various industries complicates it until the head spins. Meat packers must steam and wash the interior of trucks daily as a sanitary measure. Obviously if they are going to be washed inside they might as well get a beauty treatment outside. Shifting inside and outside a building for this daily ritual assumes formidable proportions.

Bakeries load trucks in the wee hours of the morning and must maintain some semblance of temperature control to guarantee the quality of the product. Public utility crews do not like wet tools and frozen ropes. This could go on and on. Each operator you talk to can think of another reason for not storing outdoors. Nevertheless they all have an eye on the cost sheet . . . so most of them will store at least some part of the fleet outdoors.

Antifreeze Contamination . . .

. . . in crankcase oil, due to leakage of glycol-type coolants, can be determined by simple field tests to check possible damage from resinous deposits.

BASED ON PAPER BY **George J. Liddell and Ruth Marshall,** Sun Oil Co.

LEAKAGE of coolant by way of the gasket can create sludging difficulties and cause engine damage, depending upon the quantity and type of coolant getting into the oil. If the coolant is only water and the leak is small, it may be removed through the ventilating system. The situation is similar with alcohol, since most antifreeze alcohols will vaporize unless the leak is excessive or the crankcase temperatures extremely low.

The situation with glycol-type antifreezes is more complex. The glycol will not readily evaporate and even with small leaks there will be some accumulation. Subjected to the same localized high temperatures and the same oxidizing conditions as the oil it may well form resinous materials in critical areas of the engine and do damage. To test for the presence of glycol the following procedure can be used:

1. Shake oil thoroughly with water in a separatory funnel.
2. Allow oil and water layers to separate.
3. Draw off water, which contains any water-soluble materials.
4. Discard the oil.
5. Filter the water to remove remaining oil.
6. Treat the water with potassium periodate and acid which will produce formaldehyde from any glycol sample.
7. Use acid fuchsin indicator to show whether formaldehyde is present.

For field tests, steps 3, 4, and 5 can be eliminated by ignoring the oil layer, and step 6 can be combined with 1 by introducing the oil into a solution containing the acid and periodate. For winter use solutions can be made up with 50% methyl alcohol instead of clear water. The test indication will not react to monohydric alcohols such as ethyl or methyl alcohols, or other aldehydes. This practically eliminates false indications from other materials, including the aldehydes, which are sometimes passed into the crankcase as the products of fuel combustion. (Paper, "A Test for Antifreeze Contamination in Crankcase Oil," was presented at SAE Annual Meeting, Detroit, Jan. 17, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Based on Discussion

By H. C. Mougey
General Motors Corp.

THE advantage in the test lies in helping to locate the real cause of trouble, when that trouble is caused by permanent antifreeze and not by low quality lubricating oil, thus helping in the taking

of the necessary steps to eliminate the trouble. Experience with the test shows that when the results are negative there is no permanent antifreeze in the sample of oil, but in some cases there have been positive results when no permanent antifreeze was used in the cooling system. The best use of the test seems, therefore, to indicate the probability of glycol in the oil, but that samples thus screened should be sent to the laboratory for confirming tests.

By C. S. Hansen
The Pure Oil Co.

THE test has been useful in explaining unusual conditions such as "freeze ups," heavy varnish deposits and unusual sludge conditions which could not be reconciled with oil quality and operating conditions. In one year's experience with the test, glycol contamination has been picked up in about 5% of the total samples tested. This shows that leakage does occur though infrequently.

By D. H. Green
National Carbon Co.

IT has been found that the identifying red or purple color may be obscured by dispersed material in very dirty oil, particularly the detergent type, since there is not always complete separation. Because the method identifies water soluble aldehydes and not glycol, there is possibility of false positive indication from similar aldehydes which might conceivably come from such sources as butyl Cellosolve, a glycol derivative used for removing engine deposits, and polyglycol derivatives in synthetic motor oil.

It is strongly recommended, as the only constructive approach to this problem, that the spotlight be turned on basic mechanical causes—defective water jacket conditions—and that antifreeze, oil, and motor vehicle industries get together to correct them in maintenance, production, or design. Emphasis placed on the effects of glycol contamination should not minimize the cause or retard the progress being made toward production and maintenance of leak-tight engine water jackets.

By F. S. Wood
Standard Oil Co. (Indiana)

TO ascertain what effect various motor oils may have on valve-lifter sticking in the presence of glycol contamination, a series of laboratory-engine tests were run, using a number of premium heavy-duty oils and a relatively "clean" fuel. It was found that lubricating oils differ greatly in ability to cope with deposits arising from the presence of glycol in the crankcase. Until engine design has progressed to the point of preventing leakage under all conditions, the oil used may be an important factor in valve-lifter sticking.

Total Energy Concept Applied to Climb . . .

. . . of turbojet fighters results in more advantageous climb schedules than those based on consideration of potential energy alone, the Navy finds.

BASED ON PAPER BY **Rear-Adm. W. V. Davis, Jr.** Office of Chief of Naval Operations

SINCE potential and kinetic energy are mutually convertible, the rate of storing total energy—rather than potential energy alone—is the important parameter. Thus reasoned R. A. Fuhrman of the Naval Air Test Center.

He has developed a method of determining optimum climb speeds based on total energy from the result of level-flight acceleration runs. The Navy is using this method instead of the old "sawtooth" method. That called for studying the aircraft at some arbitrary climbing speed and measuring the time required to pass from one level to another. Various speeds had to be tried for each altitude increment of 1000 ft or so. From these data, schedules of best climb speed for various altitudes were prepared for use of pilots in intercept problems.

Schedules prepared by the new method save climb time. In one particular type of airplane, climb conducted according to the schedule for best rate of storing total energy takes 7-10% less time than one based on maximum rate of climb.

Airspeeds on best-energy schedules are higher at all altitudes up to the absolute ceiling, where the two schedules must, of course, coincide.

(Paper, "Flight Test and Facilities for Naval Aircraft," was presented at SAE National Aeronautic Meeting, New York, April 21, 1952. Complete paper contains sections on history of the naval air test facilities, air speed calibration, powerplant performance measurement, stability and control tests, and carrier suitability as well as material on climb schedules. Paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Humphreys Engine Provides

THE Humphreys engine is a conventional powerplant to which has been added a device for automatically varying the clearance volume of the combustion chamber. This allows the compression ratio to be varied so that:

1. At light loads the compression ratio is at a maximum, providing best thermal efficiency and therefore lowest fuel consumption.

2. At intermediate loads the compression ratio is somewhat lower but still high enough to provide good thermal efficiency and therefore low fuel consumption.

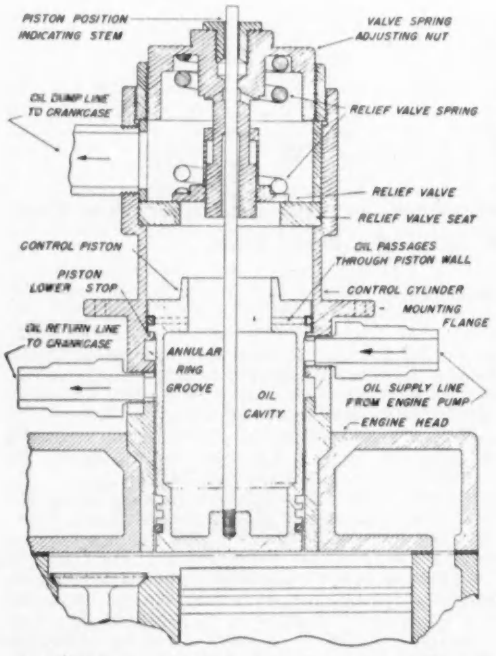


Fig. 1—Constructional details of Humphreys constant-compression unit

3. At full load the compresison ratio is at its lowest point, so that the engine is able to operate without knock with fuels of quite low octane number.

Variable Compression Ratio

This variation in compression ratio is accomplished, not in a single step, but grudgingly—one might say—in an infinitely variable manner in accordance with torque demand, so as to provide constant compression pressure over the driving range. Thus, the high compression ratio needed to provide the required compression pressure at part load can be lowered gradually as the torque is increased until at full load the engine has been returned to its original design compression ratio.

Description of Engine

In the Humphreys engine the combustion chamber has been modified so as to allow the addition of a movable piston, as shown in Fig. 1.

A control cylinder is mounted vertically above the power cylinder with its inner end opening into the combustion chamber. The upper section of the control cylinder is secured to the lower section by studs projecting from the cylinder head through a mounting flange. Within the control cylinder there is a freely moving piston, enlarged at its upper end to provide oil-cushioned limit stops.

To indicate at all times the position of this control piston, there is provided a light rod stem extending from the crown through the top of the unit. A generously proportioned, spring-loaded relief valve closes the top of the control cylinder. The tension of the spring may be varied with an adjusting nut. The space above the relief valve is open to atmospheric pressure. A large oil dump line connects to this space.

Between the inner crown of the control piston and the relief valve seat is an oil cavity in which fluid is always present. This cavity is supplied with lubricating oil from the crankcase of the engine by the lubricating oil pump. The inlet passage is indicated at the right side of the drawing.

Operation of Engine

Oil, at the system pressure, is forced into the oil cavity by way of an annular ring in the cylinder wall, then through a restricted passage around the piston lower stop to a ring groove in the enlarged section, and thence through drilled passages in the

Variable Clearance Volume

W. H. Paul and **I. B. Humphreys**
Oregon State College — Humphreys Investment Co.

Excerpts from paper, "Humphreys Constant-Compression Engine," presented at the SAE National Fuels & Lubricants Meeting, Chicago, Oct. 31, 1951, and at the SAE National West Coast Meeting, San Francisco, Aug. 11, 1952. This paper was published in full, including the discussion, in the April SAE Quarterly Transactions.

piston wall. Obviously, there is a considerable pressure drop through this restricted passage, but such is necessary in order to retain the oil in the cavity under conditions of fluctuating pressures.

An oil return line (shown at the left) serves to collect leakage from the annular ring in the supply line. This line also bleeds off any combustion gases that may leak past the auxiliary piston. The maximum travel of the auxiliary piston is approximately 1¼ in. in the experimental engines. The movement of the auxiliary piston varies the compression ratio from about 6½ to 14.

Since the principal purpose of the auxiliary control piston is to maintain constant compression pressure automatically with change in load, let it be assumed that the load is light, such as at idling or some low level-road speed. The control piston is maintained in its highest compression ratio position (lowest position in cylinder) by virtue of the fact that the oil cavity is full and there is no appreciable flow through the relief valve or any of the other outlets. With a manifold absolute pressure of about 6 psi and a compression ratio of 14, the theoretical compression pressure will be about 200 psia.

Let the throttle suddenly be opened fully. On the first cycle the compression pressure and the resulting maximum pressure will be high. This high pressure is communicated to the oil in the oil cavity

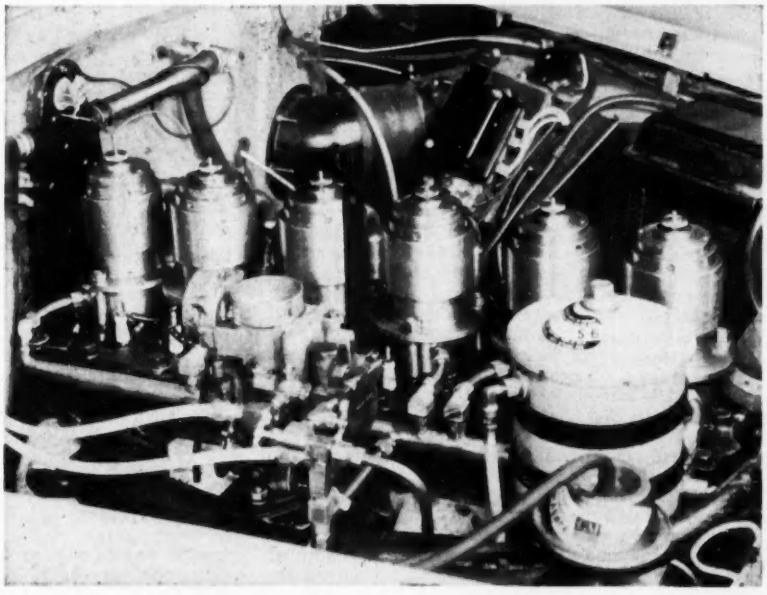


Fig. 2—Humphreys units installed in engine of Oldsmobile 76 car

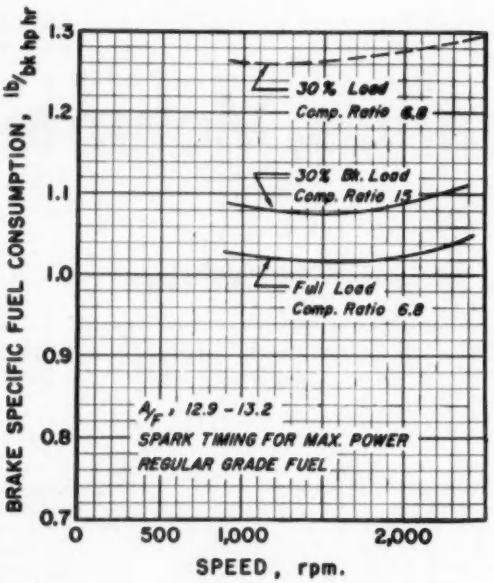


Fig. 3—Brake specific fuel consumption of Wisconsin engine equipped with Humphreys conversion

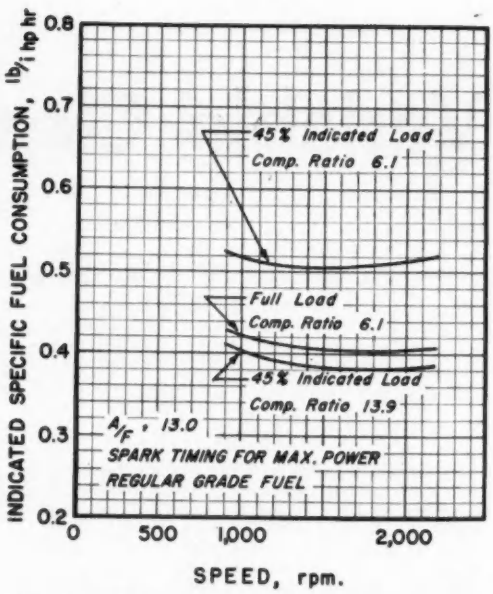


Fig. 4—Indicated specific fuel consumption of Willys engine with Humphreys conversion

and acts to open the relief valve. Due to the liberal size of the relief opening the oil is discharged quickly into a region of atmospheric pressure. The discharge of oil allows the control piston to move sharply toward the opposite extreme. The termination of upward travel is cushioned by oil partially trapped between the under side of the relief valve seat and the shelf on the piston. The control piston will remain in the top of the cylinder position as long as the load is full or heavy, that is, as long as the pressure within the engine cylinder transmits a force to the relief valve in excess of the spring loading.

During the time in the cycle when the gas pressure is low, the pressure produced by the lubricating oil pump will tend to force the piston down toward smaller clearance volume. On the next cycle the combustion pressure will force it back. Thus, at full load there is a very slight, but noticeable, oscillation of the control piston. Some small amount of oil is being fed in and dumped each cycle. Under full load the manifold absolute pressure will be about 14 psi and a compression ratio of approximately 7 will produce a theoretical compression pressure of 200 psia, the same as at the lighter load with a compression ratio of 14.

Consider an intermediate load (say 40%), where the control piston comes to rest at some fractional part of its travel. Assume this load is attained instantly from idle. To have left its lower position there must have occurred a cycle in which the maximum pressure was high enough to open the relief valve. This would allow the piston to move upward and decrease the compression ratio. Such movement would lower the maximum pressure on the next cycle. If the maximum pressure were not high enough to open the relief valve, the control piston would recede to a point of higher compression ratio. The next cycle would dump a little oil and reposition the piston. Thus, there is a constant motion of the piston caused by the combination of oil relief and supply. At such an intermediate load it may be estimated that the manifold absolute pressure would be about 9 psi. A compression ratio of about 9.5 would give the constant compression pressure of 200 psia.

Under light load (up to about 30% of maximum brake horsepower at any speed) most gasoline engines will tolerate 12/1 compression ratio without knock with regular-grade fuel. Up to about 55 mph on a level road, the Humphreys adaptation to the Oldsmobile 76 engine operates on regular-grade fuel without knock with the control piston in the highest compression ratio position. That highest compression ratio is about 14, while the lowest is approximately 6.5.

When the relief valve springs are set barely to open under full load, they keep the relief valve completely closed at all loads less than about 30%. This means that the present Humphreys design operates as a fixed high-compression-ratio engine in the first 30% of its load range.

Engines Equipped with Unit

Three different engines have been equipped with the Humphreys constant-compression unit. All may be considered experimental, and subject to such improvement as could be effected by addi-

tional engineering talent and manufacturing techniques.

The first engine was a single-cylinder aircooled Wisconsin of 38.5 cu in. displacement and about 8 hp at 1800 rpm. The preliminary performance studies on this engine indicated that substantial gains in economy were possible. It was, therefore, decided to apply the development to a multicylinder engine. A new, late-model 4-cyl Willys of 134 cu in. displacement was available. This engine is rated at 60 bhp at 4000 rpm.

The third engine to which the equipment was adapted was a 1949 Oldsmobile, model 76. This uses a 6-cyl L-head, liquid-cooled engine, with a brake horsepower rating of 105 at 3400 rpm. Fig. 2 shows the completed installation. The oil inlet gallery with its outlets to the several units is visible here.

Performance

All of these engines operate smoothly, have good throttle response, are quiet, and they idle exceptionally well. In fact, it can be said that the summation of all external characteristics of the Humphreys engine (its personality) is essentially the same as that of a conventional engine. In the matter of reliability the Oldsmobile conversion has now been operated in the car for more than 25,000 miles, over all types of terrain, from near sea level to 14,000-ft altitude, and throughout two complete cycles of seasonal variation in temperature. During this entire period there have been no stuck pistons or rings, no broken springs, or any maintenance of major importance.

All three engines have been tested for power and fuel consumption. In addition, the Willys and Oldsmobile engines have been examined for lean-mixture performance.

The single-cylinder Wisconsin engine was loaded in the laboratory by a belt connection to a small electric dynamometer. The usual provisions were made to control and observe operating characteristics. Fig. 3 shows the brake specific fuel consumption of this engine when equipped with the Humphreys conversion. Over a range of speeds, the part-load economy curve for 15/1 compression ratio lies above, but fairly close to, the full-load curve representing 6.8 compression ratio. This, of course, is what might be expected, but a definite improvement in part-load economy is apparent from a comparison of the 15/1 compression ratio part-load curve with the 6.8/1 compression ratio part-load curve shown uppermost in the group.

There was no provision in the Wisconsin test setup to measure engine friction, so we decided to shift the test program to the Willys engine, on which more fundamental studies could be conducted.

Again the problem was principally one of determining the full- and part-load fuel consumption. A load of 45% on an indicated basis was found to closely approximate a 30% load factor on a brake basis. Similar runs were made to those described for the Wisconsin engine except for friction determination, as shown in Fig. 4. Note that the 45% indicated load economy is slightly superior to the full-load performance. The difference between the two curves is small (less than 2%), so it may be concluded that, within the combustion chamber, it is possible to equal the full-load economy by increasing the compression ratio. The total gain is indicated by the difference between the upper (45% and 6.1 compression ratio) and lower (45% and 13.0 compression ratio) curves.

In addition to gains in thermal efficiency resulting from increased compression ratio, further gains in fuel economy may be realized by taking advantage of the fact that leaner mixtures may be burned, with little loss in power, if the charge is compressed to a higher pressure. This possibility was investi-

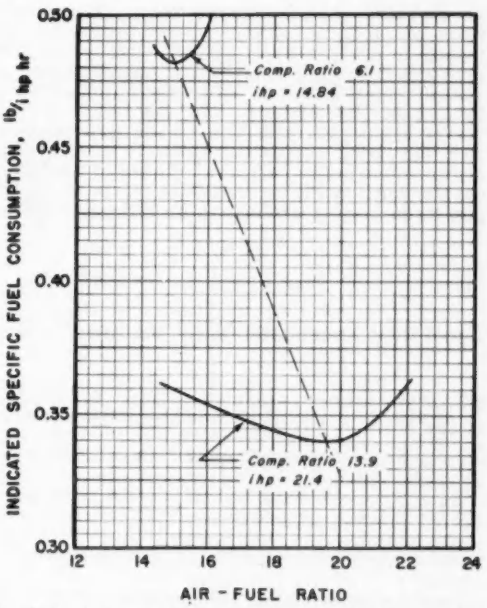


Fig. 5—Constant-power isfc curves for Willys engine with Humphreys conversion—45% load, 2000 rpm, regular-grade fuel

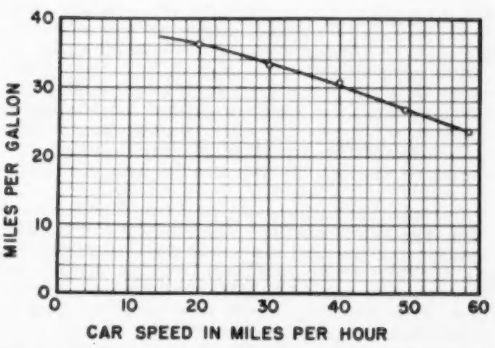


Fig. 6—Level-road constant-speed mileage of Oldsmobile equipped with Humphreys conversion

gated in connection with the Humphreys engine development by using the Willys engine with the variable-compression-ratio feature. Inasmuch as typical basic results would be obtained at any speed, the study was confined to the one constant speed of 2000 rpm. By keeping the indicated power constant at 45% of maximum and fixing the compression ratio, the air/fuel ratio was varied over a considerable range. Fig. 5 shows two fuel consumption curves obtained by this procedure. It will be noted that the 6.1 compression ratio curve attains a minimum indicated specific fuel consumption at around 15/1 *A/F*, while the 13.9 compression ratio curve reaches this optimum point at the much leaner air/fuel ratio of approximately 19.5/1. These optimum points do not shift when the results are reported on a brake basis. Noteworthy, also, is the apparent flatness of these curves, indicating only a limited improvement in isfc with a considerable leaning of the mixture. The separation of the curves again calls attention to the possible gain from increasing compression ratio. Note that these are constant-power curves, which means that this engine, when operating at 30% of maximum brake power, on regular-grade fuel, at 13.9 compression ratio, could be fed an *A/F* of 19.5 to obtain maximum economy.

Road Tests

In addition to numerous checks of trip mileage, our Oldsmobile with the Humphreys conversion has been carefully tested for its single-mile, constant-speed fuel consumption. These tests were made in Denver, at an altitude of approximately 5000 ft, which, if anything, would cause the mileage to be lower than that obtainable at sea level. Fig. 6 shows the mileage curve. It was obtained with regular-grade fuel and represents, over its entire range, operation at about 14/1 compression ratio.

Air/fuel ratio, although not accurately determinable, was estimated to be about 17/1. It will be noted that the 50 mph mileage of this car is about 26.5. At this speed 17.5 mpg is the comparable normal mileage.

Neither the top speed nor the hill-climbing performance of the car have been impaired by the application of the Humphreys unit.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Economy Increases Will Be Small, Discussors Say . . .

SEVERAL discussers pointed out that one cannot expect the constant-compression engine to give as much improvement in economy as the high constant-compression-ratio engine. Two reasons were given for this.

First, a fixed increase in compression ratio is reflected in improved fuel economy at all speeds and loads, whereas the improvement occurs only at part-load operation with the constant-compression engine.

Second, the increased horsepower and torque of the engine with higher fixed compression ratio permit the use of a lower rear-axle ratio or a smaller engine (or both) without a loss in performance. The Humphreys engine, on the other hand, does not boost engine output at full throttle, so that the axle ratio cannot be reduced unless we are willing to accept a loss in acceleration performance.

The general feeling among the discussers seemed to be that the Humphreys engine is the hard way of doing what can be accomplished more easily in other ways. For instance, reducing the engine friction appreciably would yield much better fuel economy without an increase in octane requirements.

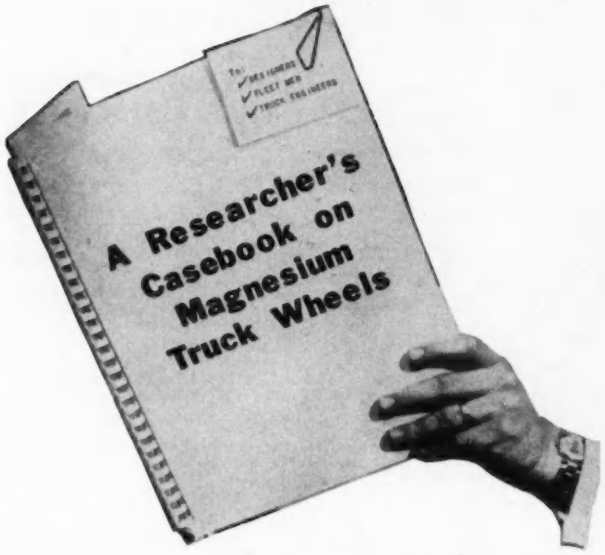
In reply, the authors admitted that the engine of high fixed compression ratio does appear to offer greater possibilities for lower fuel consumption, simplicity of design, and higher specific output than their engine. The high fixed-compression-ratio engine, however, they emphasized, requires fuel of more than 100 (F-2) octane number, whereas their engine can get along with fuel of normal octane number.

In a broad sense, they added, it would appear that the constant-compression principle is applicable to any engine, regardless of compression ratio. Accordingly, they accepted the discussion regarding higher compression ratios, lower axle ratios, smaller engines, and higher outputs, subject to the consideration that the constant-compression principle could be superimposed on such improvements and still be advantageous at conditions of less than full-throttle operation. They consider the constant-compression principle not a substitute for any feature of high compression ratio but rather, as had been stated by one of the discussers, as a means of providing a variable expansion ratio, which the conventional engine roughly approximates by timing.

To the criticism about the mechanical feasibility of the engine and its knocking characteristics, the authors replied as follows:

"The engine does not detonate or preignite. The control piston is amply cooled by the large quantity of oil that is ever circulating inside it. In no instance have the auxiliary pistons frozen nor have the rings on the auxiliary pistons failed to provide adequate seal. . . . The problems of sealing and deposits are similar to those of the power piston. The dump-valve seal is always flooded with a film of lubricating oil. Its tendency to stick is considered to be no greater than that of an hydraulic valve lifter.

"Impaired breathing capacity due to valve location was experienced in the Wisconsin and Willys engines. The relief provided between the valve heads and the cylinder in the Oldsmobile has apparently corrected this shortcoming, as evidenced by the hill-climbing and top-speed ability of the car."



Marvin H. Polzin, Head, Research Section, Wheel & Brake Division, Goodyear Aircraft Corp.

Excerpts from paper, "Magnesium Alloy Truck Wheels Evaluated Analytically," presented by title at SAE Annual Meeting, Detroit, Jan. 15, 1952.

FLEET men eager to replace vehicle dead weight with payload have gone to light-weight metal bodies. Magnesium wheels also may fit into this weight-reduction pattern. But getting the most out of magnesium calls for a wheel design that puts the metal where it's needed. Experimental stress analysis can be a big aid to redesign, our experience has shown.

Before you go about replacing one material with another in a product, you've got to know how they stack up against each other. How do they compare on the properties that are important for that product? Match it up against steel for use in a wheel and magnesium comes out with a pretty good record. That goes for physical properties, corrosion resistance, and resistance to maintenance damage.

It's in bending that magnesium shows one of its biggest features. For a given weight, a magnesium section can be about four times as thick as a steel section. Stress on the surface varies inversely as the square of the thickness. So suppose we take equal-weight rectangular beams of magnesium and steel having equal length and width dimensions, subjected to the same bending load as shown by beams 2 and 4 in Fig. 1. Here is what happens:

The maximum stress on the steel will be 16 times the maximum stress on the magnesium.

The deflection of the steel beam will be about 14 times that of the magnesium beam.

The endurance limit[1] fatigue stress of magnesium in completely reversed bending will range from one-sixth to one-half that of steel depending on the particular alloy and type of fabrication compared.

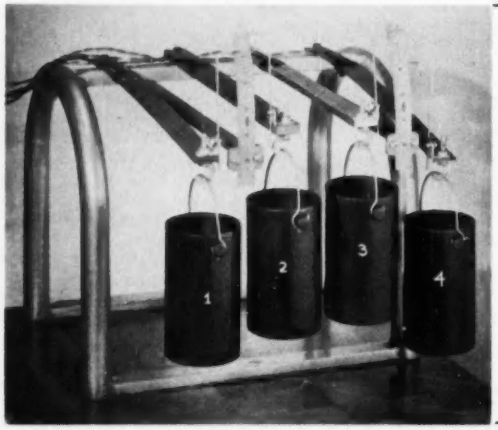
Suppose we again use a rectangular beam of magnesium with length, width, and bending load equal to that of a high strength steel beam, adjusting the thickness so that each is being stressed to its endurance limit. In this case the magnesium beam weighs roughly half as much as the steel beam. Compare beams 1 and 4 of Fig. 1.

So you can predict that of two rectangular cross-section beams—one of magnesium, the other of steel—varying the thickness dimension only, the magnesium beam can provide fatigue performance equal to that of the steel beam. And at the same time the magnesium beam will weigh only half as much and deflect less than half as much.

In the final analysis many other factors must be considered. But this illustrates the basic relations from which magnesium derives its performance ability.

Thus if magnesium is substituted weight for weight, the performance of the steel structure can certainly be equalled. But economics of raw materials and manufacturing today make this a losing proposition. On the other hand, magnesium with a much lower modulus of elasticity and lower allowable fatigue stresses than steel obviously cannot be substituted volume for volume with steel and

[1] The endurance limit of magnesium referred to is technically the fatigue limit at 10^7 cycles. For all practical purposes it can be called endurance limit because the fatigue limit at 10^9 cycles is only slightly lower than 10^7 cycles.



MATERIAL		MAGNESIUM	ALUMINUM		STEEL
BEAM No.		1	2	3	4
THICKNESS		.202	.375(3/8)	.250(1/4)	.093(3/32)
LENGTH & WIDTH		SAME			
$\frac{Mc}{I}$ (h=THICKNESS OF STEEL BAR)		$\frac{6M}{(2.2h)^2b}$	$\frac{6M}{(4h)^2b}$	$\frac{6M}{(\frac{8}{3}h)^2b}$	$\frac{6M}{h^2b}$
WEIGHT (GRAMS)		84	152	157	165
DEFLECTION WITH 5.7 LBS. LOAD		$\frac{13}{16}$	$\frac{5}{32}$	$\frac{9}{32}$	$1\frac{3}{4}$
MEASURED STRESS WITH 5.7 LBS. LOAD		9360 PSI	2730 PSI	5660 PSI	46,800 PSI
STRESS RATIO	CALCULATED	3.3	1	2.25	16.0
	MEASURED	3.4	1	2.06	17.0
WEIGHT RATIO		.51	.92	.95	1
ENDURANCE LIMIT (10^7 CYCLES, R=-1, SCF=1)	ROTATING BEAM -WROUGHT	22,500 PSI		26,000 PSI	62,500 PSI
	PLATE BENDING -CAST	12,500 PSI		9,000 PSI	

Fig. 1—The demonstration unit at left compares the bending properties of magnesium, aluminum, and steel, tabulated at right. Note that for equal weight beams, the magnesium beam (2) has one-sixteenth the stress of the steel one (4)

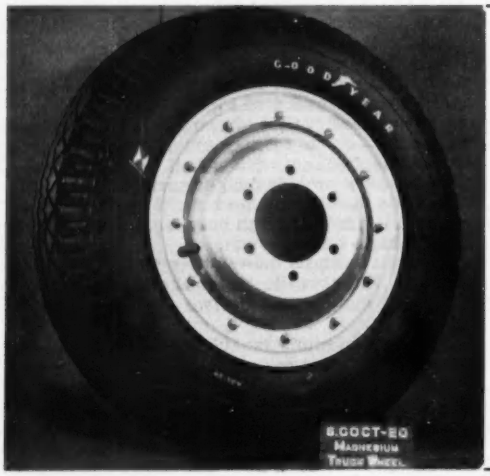
expect to compete in performance.

Somewhere between these two extremes can be found a design which is mechanically and economically sound—a design which will achieve the desired performance with the least weight. The shortest route to this design is not through any straight substitution formula, but by thorough analysis of an existing design under actual service conditions in which actual working stresses are measured. Once these facts are known, the redistribution of the material to promote the highest degree of design efficiency is much more straightforward. As far as practicable every ounce of metal must be made to do its fair share of work.

Logically enough it follows that magnesium lends itself to this redistribution better than steel because there are thicker sections to utilize. The steel sections often are already so thin that it is hardly practical from a manufacturing standpoint to design them any thinner.

Talk to fleet men about magnesium wheels for truck service and the first thing they want to know is: How do they stand up against corrosion and maintenance damage?

Our experience on ground vehicles is very limited. However, for a good many years most airplanes have been equipped with magnesium wheels. These wheels have not shown corrosion to be a serious problem. True, magnesium requires protective coatings. But all of us know what happens to a bare piece of ordinary steel exposed to the weather for a few months. Exposure tests at Kure



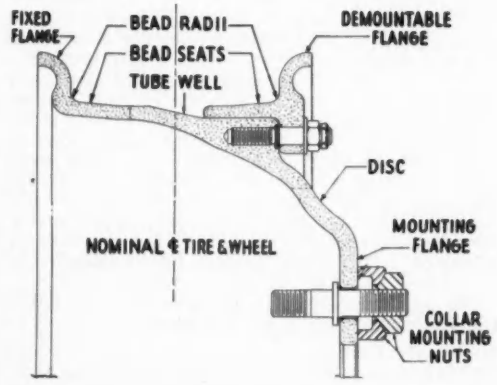


Fig. 2—The wheel tested is shown at left and its cross-section at right

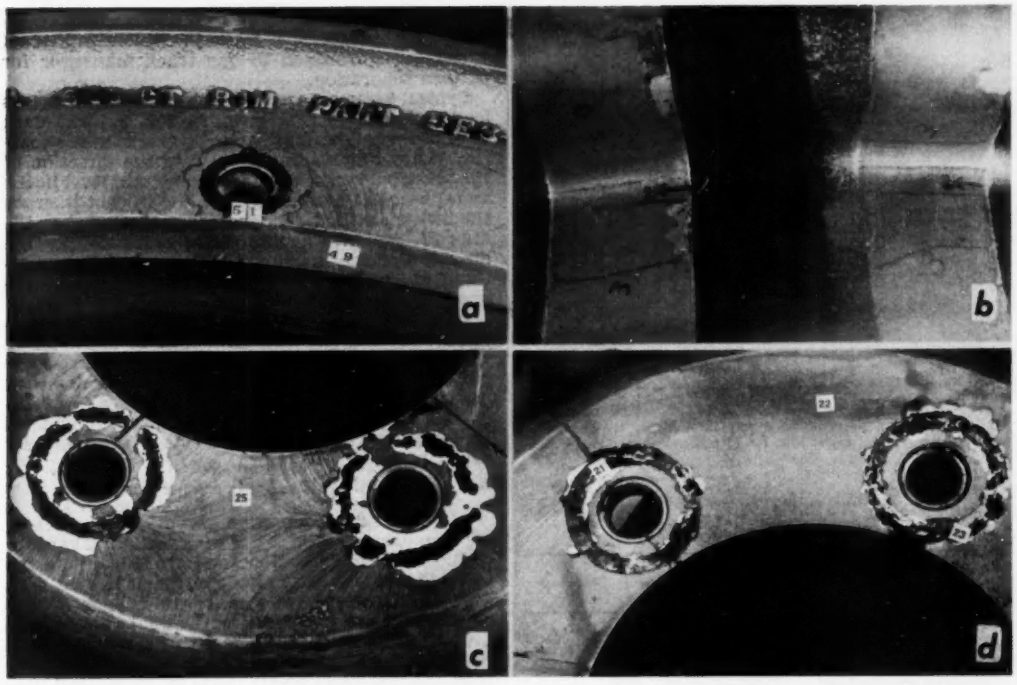


Fig. 3—These are various Stresscoats patterns gotten from the following loading conditions: (a) bolt tightening on the demountable flange, (b) tire inflation, on the flange bead seat, (c) truck turning, on the wheel mounting flange, and (d) braking torque, on the wheel mounting flange

Beach, North Carolina, have vindicated magnesium to a considerable extent.

Magnesium is a relatively soft metal. The indiscriminate use of tire irons, hammers, and long-handled wrenches by burly mechanics in tire dismounting and wheel assembly can be murder to a magnesium wheel. The damage unfortunately is not manifested at the moment so that the mechanic can see it, but later as premature fatigue failures caused by notches and excessive preloads. In the same way damage can be done to steel wheels, although no doubt to a lesser degree.

We feel the big fleet operator has begun to realize that careful maintenance pays off, regardless of the metal used. Except in emergencies, he has discontinued slam-bang maintenance methods. Drawing again from aircraft experience, the average airplane tire is much more difficult to mount and dismount than the average truck tire. Although some failures have been attributed to maintenance damage, the problem has been a minor one.

Once you agree that a new material has attractive possibilities for your product without too serious penalties, you've got to find how to design your product of it. Through experimental stress analysis we analyzed a wheel's performance in actual road service. Facts learned by this approach were applied to another wheel design.

The preliminary design was a 6.00 CT-20 wheel of a conventional bowl shape with a bolted-on demountable flange. It was to be made of Dowmetal A-T4 and an 8.25-20 tire was used. See Fig. 2. This wheel as tested was about 35% lighter than a steel wheel of the same size and type.

Since information regarding load factors or load components which could be expected in various truck maneuvers was very limited, it was decided to start from scratch and make the truck the laboratory. Loads were varied by using sand bags; 3000 lb was considered rated load on the test wheel.

Although it was intended that the final fatigue analysis should come from strain gage readings, it was felt that locating the gages at random was an offense even more grievous than assuming the load components themselves. The Ouija board was given some consideration, but reliable operators being at a premium, the brittle lacquer, Stresscoat, was chosen instead as the gage-locating medium.

Brittle Lacquer Spots Strains

Since Stresscoat is very sensitive to temperature and humidity changes, February weather would hardly be judged ideal for outdoor Stresscoat operations. It was only after considerable anxiety that the job was begun. Patterns were gotten from assembly and tire inflation loads under controlled atmospheric conditions. Then one wheel was coated and run on the truck through straight driving, turning, and braking maneuvers at overload conditions to determine approximately the operating strain levels.

This information was then used to plan the proper

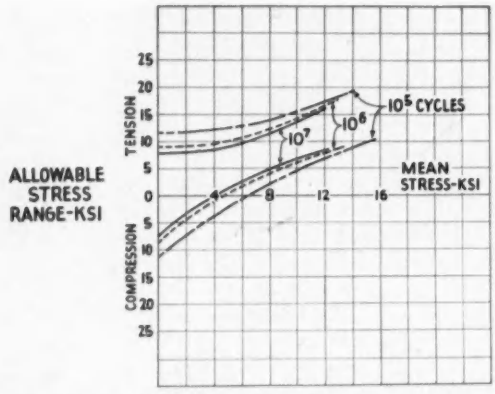


Fig. 4—Fatigue data for Dowmetal A-T4 magnesium alloy shows that the allowable stress range is very little higher for one million cycles than for 10 million

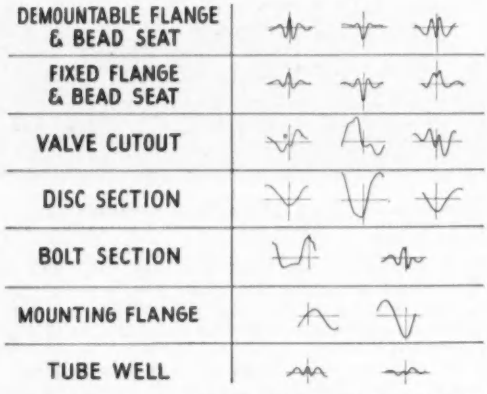


Fig. 5—Typical strain wave shapes for one revolution of the wheel in straight driving

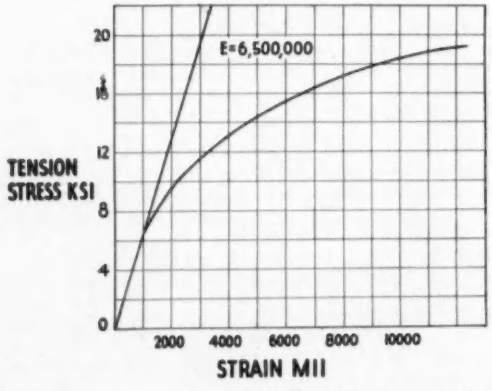


Fig. 6—Stress-strain curve for Dowmetal A-T4 magnesium alloy

combination of load severity and Stresscoat sensitivity for subsequent tests in which individual wheels were confined to one truck maneuver for pattern separation.

Typical Stresscoat patterns obtained from various load components are shown in Fig. 3. The dark lines in these figures are actually cracks in the coating. They occur perpendicular to the direction of the principal strain whenever the strain level in the metal becomes high enough at any instant to crack the brittle coating. These crack patterns locate the area of strain. The individual crack defines the direction of the maximum strain. And the sensitivity of the particular coating used predicts the approximate stress level.

With strain location and direction defined for the various maneuvers, a large number of strain gages were applied to one wheel to cover all Stresscoat patterns. As much as possible, biaxial strains were measured to determine more accurately the principal strains. Gages were waterproofed and all loads brought to the outboard side of the wheel for accessibility.

Analyzing the Data

After running each gage through the series of truck maneuvers, you're left with yards and yards of oscillograph records. Now you have to weed out the insignificant and assemble the remainder in such a way that it may be of value to the designer. Considering the overall objective, the final data presentation was expected to show the relative fatigue performance of various points in the wheel during various truck maneuvers, and to indicate the degree of design balance or efficiency prevailing in the wheel for a given life expectancy.

This demanded consideration of:

1. Type of fatigue data to match conditions in the structure.
2. Method of arriving at stress values from strain readings.
3. Proper portrayal of information to the designer.

Fatigue performance is a rather fickle character and fatigue analysis at its present stage of development is anything but an exact science. So certain simplifications seemed in order. This is a breakdown of the approach used:

1. Type of fatigue data.

This choice is governed by at least the following factors: (a) kind of loading, (b) life expectancy, and (c) surface condition of metal.

a. Kind of Loading:

The Dow Chemical Co. had available plate bending fatigue data on the magnesium alloy used in the wheel. This appeared to be a logical choice since the strain gage survey of the wheel indicated primarily bending loads involved, and good correlation with service life had been found on other magnesium structures. These data were expressed in terms of mean stress and stress range for three values of life expectancy, Fig. 4.

b. Life Expectancy:

An 8.25-20 tire would make approximately 500

revolutions per mile. Assuming one cycle of stress per wheel revolution, ten million stress cycles would be made in 20,000 miles, and one hundred million cycles in 200,000 miles. As a basis for evaluation, it was assumed that the wheel would be expected to run 100,000 miles in service and that there would be one hard turn per mile (found to be the most severe maneuver), each turn lasting for ten revolutions of of the wheel. This would amount to one million cycles of turning in the life of the wheel.

According to Fig. 4 the allowable stress range is very little higher for one million cycles than for ten million. Since one million cycles of turning stress had been assumed for 100,000 miles of service, it seemed logical to set the goal at ten million cycles which in turn had very nearly the same allowable stress range as one hundred million.

In other words if the stress range could be made to fall within the ten million cycles allowable, a reasonably long service life should be expected. That's because the ordinary S-N curve for this alloy indicated a leveling off of allowable stress just before ten million cycles.

c. Surface Condition of Metal:

It has been shown that the allowable stress range for all magnesium alloys is higher for a machined than for an "as cast" surface. The "as cast" data was chosen as the criterion since eventually we would expect to eliminate as much machining as possible for economy reasons and the critical areas which would still be machined would enjoy some margin of safety.

Fig. 5 shows some representative strain wave shapes for one revolution of the wheel. For all maneuvering loads except shock loads, these wave shapes maintained themselves rather closely; the principal change was one of amplitude. Analysis of all the small intermediate cycles was not considered—only the maximum and minimum values of the complex wave. This appeared to be a permissible simplification in this case because the criterion for performance was that the *maximum* stress range must be below the endurance limit. If the metal would sustain the *maximum* stress range indefinitely, smaller ranges should be of little consequence.

2. Method of Arriving at Stress Values from Strain Readings:

A number of tensile specimens pulled from an unstressed wheel gave an average stress-strain curve shown in Fig. 6. Caution must be emphasized against using such a curve too freely however. It does define the proportional limit below which strain is converted to stress by 6,500,000 modulus. However, the stress at the proportional limit is in the order of only 6000 psi; above this point things are not too well defined.

3. Simple Portrayal of Information to Designer:

The designer needs to know at least the following:

a. Does the design meet the life requirements?

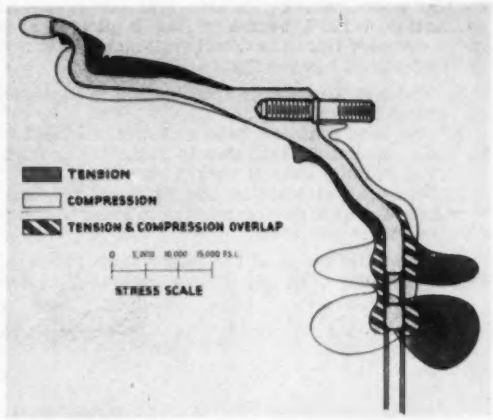


Fig. 7—Preload stresses from wheel assembly and tire inflation shown here point up weaknesses in the structure

b. How do preloads (assembly and inflation) affect the fatigue life?

c. To what extent do the various loads and truck maneuvers contribute to fatigue?

d. Where can metal safely be removed to reduce weight?

Of course, the stresses can simply be tabulated for each gage location and each maneuver. However, this maze of data makes the overall objective difficult to grasp; the graphical presentation seems much more effective. Once the overall picture is understood, individual gages may be studied in more detail.

Fig. 7 shows the graphical presentation of the preload stresses as calibrated ordinates normal to the surface of the wheel cross-section. This shows the high and low stress locations and in this case hints at the weakness in the wheel mounting flange from tightening the mounting nuts. Preload stresses are caused by bolting the demountable flange to the wheel, by inflating the tire, and by bolting the wheel to the hub. Assembly and inflation stresses are always present, defining the stress level around which the cycling stresses operate.

Fatigue Data Picture

The fatigue portrayal, Fig. 8, is perhaps a little more difficult but more informative once obtained. The fatigue evaluation is rated in terms of "percentage of allowable stress range." The measured stresses obtained from the strain gage show a value of stress range at a certain mean stress. According to the fatigue diagram, Fig. 4, there is a certain allowable stress range at this measured mean stress. The measured stress range will be some percentage of the allowable stress range.

If that percentage exceeds 100%, the metal is being utilized beyond its commitments according to the fatigue data and will fall short of the life expectancy. If on the other hand it is less than 100%, the metal is not being utilized to its capacity and suggests a weight reduction to improve design efficiency.

The percentage values are plotted perpendicular

to the wheel section contour and for graphical evaluation a 100% boundary line is plotted at a given distance from the wheel section as shown.

The designer can see that:

1. The mounting flange arrangement is weak and must be redesigned.
2. The bead seat and tube well sections need to be reduced considerably to make the most of the primary goal of weight reduction.
3. The peak stresses in the valve cutout indicate the need of streamlining to lower the concentration of stress.

Gages on the shank of the flange studs indicated bending loads, although it was obvious that the critical point would be at a location where it would not be possible to install a gage. An accelerated roll test of the wheel on a laboratory flywheel produced the failure of these shrunk-in steel studs in 16,000 miles of rolling at rated load at the location indicated in Fig. 9. It proved the need for a different means of fastening the demountable flange.

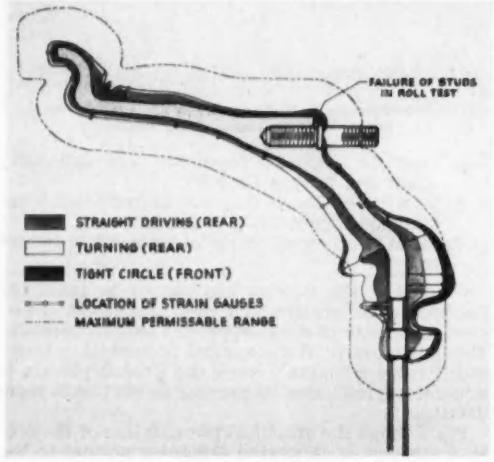


Fig. 8—This graphical fatigue evaluation shows how measured stresses compare with maximum permissable stress range. It points up design weak spots as well as inefficient use of metal

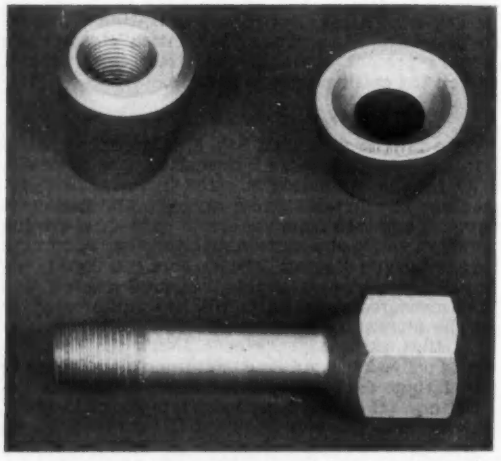


Fig. 9—Design of this bolt and bushings, for attaching demountable flange to wheel, grew out of the initial stress analysis work

Applying the Results

Up to this point we have exposed the analysis. It is only fair that we reveal the prescription. Unfortunately this particular wheel was never redesigned as such—the patient died while the diagnosis was being made. However, a 6.50-16 wheel was needed sometime after this analysis and the data proved invaluable in its design.

The original wheel failed at the base of the shrunk-in steel flange studs, Fig. 8, after 16,000 miles of rolling at rated load. Strain gages on the shank of the studs indicated considerable bending of the studs even from the tire inflation. The built-in notch at the maximum moment point was a perfect nucleus for failure. It was further shown that when the flange was removed, perhaps during a tire change, the exposed stud threads were vulnerable to damage and the studs would be very difficult to replace.

Therefore the bolt shown in Fig. 9 was designed with an undercut shank to provide stress relief at both head and threads. A steel bushing with a press fit in the flange provides a self-aligning seat for the tapered bolt head. Another steel bushing pressed into cast recesses in the wheel serves as a nut for the bolt. The threaded hole is slightly off center with respect to the recess, thus preventing turning of the bushing during assembly.

The original wheel used a collar-type nut shown in Fig. 2 for mounting on the hub. It was designed in this way to spread out the clamping stresses on the magnesium and thus avoid fatigue failures as well as wear and loosening. However, as seen in Figs. 3c and 8 the fatigue stresses around these collars were excessive. So the redesign incorporated a steel pressure ring with spherical seats to accommodate present standard truck wheel mounting nuts. This method proved to be much better fatigue-wise, more economical to manufacture, and added very little weight. The same ring is used with either duals or single wheels.

The metal redistribution job consists of removing metal where Fig. 8 had shown the stresses to be considerably below allowable, and reinforcing where the stresses were too high. It was limited somewhat by manufacturing processes and tire and rim standards. The valve slot was streamlined somewhat and five access holes provided for universal mounting as duals.

Although actual service experience on this wheel is very limited, the wheel did run some 40,000 miles on a laboratory flywheel at a considerable overload with no evidence of failure. This was enough cycles to be well beyond the knee of the S-N curve. These dual wheels and hub provided some 45% weight reduction over their steel equivalents.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

An Engineer Looks at

STYLING

James C. Zeder, Vice-President and Director of Engineering, Chrysler Corp.

Excerpts from introductory remarks made as chairman of technical session, Jan. 14, 1952, at SAE Annual Meeting, Detroit.

STYLING has come to be one of the most important single factors in automobile merchandising. It isn't just that people want their cars to be beautiful. Styling is more than just the wrapping put around a package of transportation. To many people, it symbolizes a station in life—or represents a goal to be attained. Frequently, people buy cars of a certain style because, consciously or subconsciously, they feel it expresses some facet of their personality or individuality.

Of course, there still are many who are not primarily interested in styling. Our surveys, for example, show that, in winter months, residents of the northern states generally don't give a hang what their cars look like. The cars are covered with snow most of the time, anyway. What these northerners want is a car that starts easily in low temperatures, warms up quickly, and gives dependable, comfortable transportation. Then there are other people who are interested only in the cheapest way to get from one place to the next—conveniently and safely. They don't care about the appearance of the car, as long as it satisfies that one requirement.

But, by and large, American citizens are highly style conscious. As a result, styling now plays an essential part in automotive merchandising. It works as a team with engineering in design.

Yet, styling and engineering are strange bedfellows in many ways. In engineering, for example, there usually is only one right answer to any given problem . . . or at least a limited number of right answers. But in styling, an unlimited number of answers usually is possible. The big difficulty is that everybody uses a different yardstick to evaluate the results, to tell the designer if he is right or wrong.

Styling is a game everybody can play. That's what makes it so interesting. On legal questions, most of us are willing to defer to a lawyer's opinions. To know how much a piece of jewelry is worth, we go to a responsible jeweler. If we want to redecorate a house, we are likely to solicit the advice of an expert. But when it comes to styling!!

When it comes to styling, *everybody* is an expert . . . and it's fine that it is this way. Everyone *should* feel free to exercise his own judgment about a car's appearance . . . even if this practice does make life more difficult for the stylist.

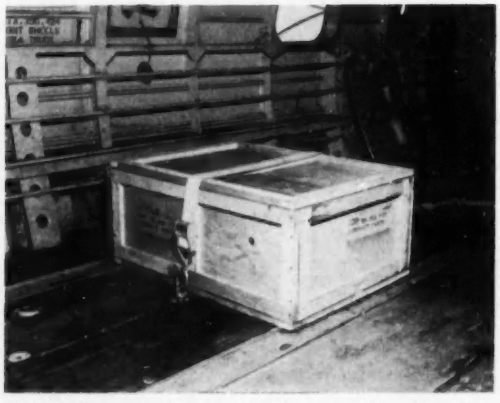
Another problem in styling is people's inclination to prize novelty very highly. All of us want some way to express our individuality. But, "being different" has no virtue in and of itself. A design must be original, but it also must be practical—and must conform to the requirements of good taste.

There still is room for improvement in American automobile styling.

Air Cargo Tie-Downs . . .

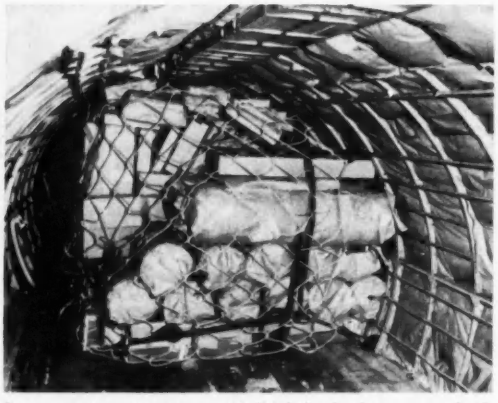
. . . need technical study. They have to hold to be safe and they must be economical. Here are ways to reach those objectives.

BASED ON PAPER BY **Chester H. Chiodo** Slick Airways, Inc.



Web-Lock, comprising heavy web strap with self-locking quick release mechanism, similar to safety belt, solved rope problem, but not the net problem.

Web-Locks, due to mechanical advantage, tore nylon nets more easily than ropes did, so rope net was tried as solution.

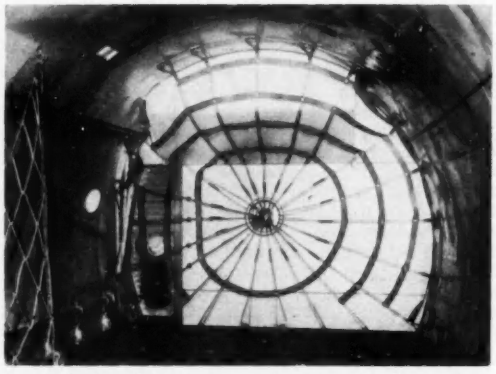


Rope net in conjunction with Web-Locks has proven both economical and practical in cargo retention.

First rope net was woven by old fisherman. Modified weave pattern and insertion of metal rings at each grid section is new method. Net rope is 3/8 in. with 10 in. grid pattern.

Cargo compartment walls, floors and ceilings must be smooth and free from breaks.

Tie-down provisions are needed on floor, wall and overhead, and fittings should be flush, easily cleaned and replaced. Units over 500 lb must be tied individually even in solid loading.



Special bulkhead net for forward portion of cabin made of heavy nylon webbing is installed semi-permanently.

It has proven more practical than permanent structural bulkhead because of webbing's resilience and lighter weight. (See top of next page for other air cargo facts.)

Based on Discussion

When asked by P. A. Wood, Jr., United Airlines, what Slick Airways regarded as sufficient strength for tie-down fittings, Chiodo replied that 3g was adequate. This brought forth further questioning regarding fittings. Olson of Douglas Aircraft wanted to know if more strength is needed than supplied by Air Force A1 type fittings. Chiodo said the DC-6A has 800 lb of one simple type of tie-down and that nothing heavier, stronger, or more complicated is wanted.

Olson then stated that it had been figured that 1 lb of gear for each 10 lb of cargo was needed for 8g restraint; but before putting any such weight on a plane, he wanted to know if that much restraint was needed. He asked what weight of gear Slick needed for 3g restraint. The answer given was 800 lb of gear for 30,000 lb of cargo and Chiodo added that while being interested in the safety of both cargo and crew, the economics of the situation has to be considered. It is not economical to carry weight to give protection in crashes that demolish a plane and everything in its path.

A question as to floor strength was posed by Cheney of Consolidated Vultee. This was answered by Chiodo who said good quality birch plywood outlasted other flooring, and that it could take loadings up to 200 psf, provided the cargo was handled carefully since most wear occurred at loading. R. D. Kelly, United Airlines, wanted to know what indoctrination was given freight handlers and was told that they were taught what floor and wall fittings could stand. The station agent and captain are both responsible for checking tie-down after the handlers are finished.

Cylinder Bore Welding Limits . . .

. . . as the White Motor Co. has set them up permit salvage of many slightly defective castings that would otherwise be scrapped.

PRESENTED here is a definition of what defects in production cylinder bores may be repaired by welding. The definition is intended to supplement the SAE manual "Repair of Ferrous Castings," which was reviewed on page 59 of the July SAE Journal.

The White Motor Co. devised the limits and has been working to them with their suppliers for both commercial and Ordnance vehicles. "At first glance, White's program looks quite liberal, but there are ample interlocking restrictions to make the plan practical," according to A. W. Demmler of Campbell, Wyant and Cannon Foundry Co. Demmler is chairman of the Gray Iron Group of Division IX-Automotive Iron Castings of the SAE Iron and Steel Technical Committee.

The White specification came to Division IX's attention during its study of castings-salvage techniques. The Division felt that SAE Journal readers who had been informed of the Manual would be interested in White's slightly different approach.

General Welding Limits

No more than eight welds will be allowed in any one bore.

No more than 30 welds will be allowed in any one block.

No welding will be allowed wherever the defect is backed up by less than one-half the fininshed wall thickness of sound metal.

Two or more defects spaced closer than the minimum shown in Table 1 shall be considered as single defects (as if the separating metal were not there).

Gas Holes

Defects in this class are clean gas holes (or blow holes), approximately circular, generally hemispherical, and seldom extending deeply into the metal. Under light, these defects will show clean metal and require very little, if any, cleaning prior to welding. These defects, while most conspicuous, can generally be waived with a greater degree of assurance than other types of defects. When under 1/32 in., they should not be opened up or probed in any way.

Pin Holes (Porosity)

Defects in this class show an unsound spongy or porous condition and are variable in both extent and

depth. Small areas should be probed to determine extent, cleaned, and if within limits, welded.

Inclusions

Inclusions may be sand, slag, or globules of chilled metal (niggerheads). Defects in this class must be thoroughly cleaned out prior to welding. Thin circular lines, indicating chilled-metal inclusions, should be looked for.

Miscellaneous Defects

Bore defects other than those given above will show from time to time. These will be individually handled as decided by inspection supervision. Disposition will not necessarily follow the general welding rules given for the more common type of defects.

Table 1—Allowable Welds

	Holes Under 1/32 In.	Holes Over 1/32 But Under ⅛ In.	Holes Over ⅛ But Under ¼ In.	Holes Over ¼ In.	Maximum Allowable Welds in This Area per Bore
Above or Within Ring Travel	Accept without welding. Limit: 5 Spacing: ⅛ in. min	Weld. Limit: 5 Spacing: 3/16 in. min	Weld. Limit: 3 Spacing: ¼ in. min	Scrap.	5
Below Ring Travel	Accept without welding. Limit: 5 Spacing: ⅛ in. min	Weld. Limit: 5 Spacing: 3/16 in. min	Weld. Limit: 5 Spacing: ¼ in. min	Weld up to ⅜ in. Scrap over ⅜ in. Limit: 1	6

Government Control . . .

. . . of aircraft development in Britain came about because private industry lacked the necessary money and resources to do the job without support.

BASED ON PAPER BY **S. Scott Hall,** British Ministry of Supply

THERE was a time when aircraft constructors could develop private ventures, but today the cost of developing any new aircraft, except the smallest and simplest, is such that it cannot be done without government support.

Large resources are needed to develop the airframe, structures, and equipment. Elaborate test flying facilities are required. Development of a new engine involves even more money and effort.

In the United Kingdom it has been felt for some time that these general arguments hold good for civil transport planes as well as military planes, and in the United States the Civil Prototype Bill and the recent report by the Foreign Survey Group of the CAA Prototype Aircraft Advisory Committee lead one to believe that America also is beginning to feel that government support is necessary in this field. In any case, it has been said with truth that "civil aviation rides home on the back of military development."

Possession of money and resources leads inevitably to control. How to ensure that this control is wisely exercised, that development proceeds on the most profitable lines, that duplication of effort is reduced to a minimum, and that the taxpayer's money is not wasted in the process? In Great Britain it is believed there has evolved a government organization and a system of collaboration between it and private enterprise which meets requirements. (Paper "Government Collaboration in Aircraft Development," was presented at SAE National Aeronautic Meeting, New York, April 22, 1952. It is available in full in multilithographed form from SAE Special Publications Dept. Price: 25¢ to members; 50¢ to nonmembers.)

Discussion: **By A. W. Dallas,** Air Transport Association

THE policy of the scheduled airlines in the U. S. is that private industry should finance development of large prototype transport aircraft, but local-service operators feel government assistance is necessary for the development of a local-service airplane. It is also felt that government aid is proper and necessary for turbine-powered craft development for the purpose of improving efficiency and safety in operation, and that government should sponsor solutions of problems relating to regulatory matters in both airworthiness and operational categories.

Recent appropriations requested by the CAA for the above mentioned purposes have not been allowed, which suggests that there is little probability of direct government subsidy of commercial aviation in any form in the near future.

NEWS OF SAE

pages 71 – 83

PRODUCTION Goes!

. . . Five Forums next year; ground vehicle, tractor, Canadian, and two aero

STEENECK, who chairmanned the first SAE Production Forum in Cleveland back in 1947, has just been named chairman of a Production Activity subcommittee which will coordinate and stimulate SAE's rapidly expanding Forum program. . . . MILLER is General Chairman for the National Production Meeting scheduled for March, 1953 in Cleveland. It will be SAE's first National Production Meeting since 1948.

Production Forums Ahead

Milwaukee	Sept. 8, 1952
Los Angeles	Oct. 1, 1952
Cleveland	March 25, 1953
New York	April 20, 1953
Milwaukee	Sept. 14, 1953
Los Angeles	Oct. 7, 1953
Toronto	Oct. 29, 1953 (date tentative)

"GET your troubles and problems off your chest by talking about them." It's an old piece of advice that production men in SAE have put to work. They have gone the adage one better by getting answers to their problems with their talk-it-out formula—the SAE Production Forum.

Back in October, 1947, Bob Steeneck, Joe Geschelin, and others of a group of the SAE Production Activity came up with the Production Forum pattern (then it was called the Production Clinic). They gave it a try in Cleveland and it went over. The idea started to spread, slowly at first, to other areas. In 1953 five such SAE Forums will be held . . . in New York, Cleveland, Milwaukee, Toronto, and Los Angeles.

What's a Forum

Walk into an SAE Production Forum and you are immediately struck with the informality of the session. It's a real audience participation program because the give and take of information comes from the all of the men at the session. It's like a factory committee meeting, except that it's on an industry rather than a company basis.

Users exchange ideas with vendors. Factory men from one plant find out how their counterparts in other plants tackle certain situations. Everyday working problems get an airing. Questions run the gamut of what, when, where, why, and how.

Information swapping covers anything and everything that comes to mind. Manufacturing men at SAE Production Forums have asked questions such as:

- "What do you do about preventing loss of hand tools?"
- "When a lot of parts fails to pass sampling inspection, who should do the detail inspection of this lot—the inspection department or the department that produced the defective work?"
- "Where would an aluminum coating be used instead of ceramic coating?"
- "Why do we get soft spots on the bar stock we harden?"
- "How do boron steels fit into the gear materials picture?"

To these and other queries the panel of experts heading the sessions often has the answer. And from the floor too come suggestions, experiences, and remedies.

As one engineer said who sat in on

several Production Forums, "It's the first technical meeting at which I could pop all the small vexing problems that have been bothering me. It was also a morale booster to learn that other fellows were in the same fix on manufacturing matters that have me stumped." Most production men who have attended SAE Forums take something useful back to the plant, they report when asked.

Men who have chairmanned these Forums in the past—like Bob Steeneck, Joe Geschelin, Muir Frey, and Burt Monesmith—were unanimous in their enthusiasm for this meeting formula. "It went over with a bang!" were the reports from Cleveland, Detroit, Milwaukee, and Los Angeles.

What makes the Production Forum such a sure-fire production meeting set-up? At least three chief elements contribute to its success . . . the nature of the thing, the subjects, and the men who participate.

Anyone who's attended conventions and technical meetings knows that the backroom and corridor conversations are as much a part of the overall meeting as the formal sessions. Engineers like to barter shop talk. They feel more inclined to "let down their hair" in small group conversation.

If small group chatter goes over so well between sessions at technical meetings, why not make it part of the meeting itself, reasoned the SAE Production Activity. That's just what the Activity did.

But let's-talk-shop-talk isn't enough. Item No. 2 is what to talk about. So the Activity realized that the Forum concept would flop unless the subjects were tailored to the interests of the men who would sit in on the sessions. Local Sections were given the job of selecting topics of interest to production men in their areas. Los Angeles went heavily on aircraft manufacturing . . . electronics, forming, and plastic tooling development. In Milwaukee the local committee found interest high in welding, heat treating, and forging.

Perhaps even before setting up the right technical menu to be served comes guests themselves. SAE Production Forum planners found that getting production men right on the firing line to participate produced a down-to-earth meeting. Attracting the quality control engineer, the quality control man, and the tool designer brought the realism of everyday contact with problems in each respective area to the meeting.

Incidentally, the Forum technique has been picked up by other SAE activities. For the last three years the SAE Summer Meeting has featured Round Tables, run like the Forums, on subjects ranging from diesel air cleaners to jet engine controls.

Muir L. Frey

This year's Production Forum in Milwaukee is the second one for which Frey will be general chairman

Burt C. Monesmith

Monesmith is the main stemwinder for the Los Angeles Production Forum scheduled for this October. He also handled the job last year

Spreading the Word

Production Forums pay off in two ways. They make good meetings and produce useful material for publication. At each Forum session an engineer in the field acts as secretary and the information that comes out of discussions. These blow-by-blow reports are then published in the SAE Journal.

To cope with the mushrooming of Forums in '53, SAE Vice-President Emil Gibian and Production Activity Meetings Vice-Chairman L. I. Woolson, have come up with a useful tool. They and their committee have created a Production Forum Subcommittee to guide and steer local sections in setting up Production Forums. The Subcommittee is headed by Bob Steeneck and includes Joe Geschelin, Muir Frey, and Burt Monesmith. Men who have served as general chairmen of previous Production Forums also will be invited to serve on the Subcommittee.

Subcommittee Chairman Steeneck laid out as the first job for the group a manual on how to set up a Production Forum.

Forums Set for '52

The two Forums slated for this year are all set to go. General chairmen Muir Frey, of Milwaukee, and Burt Monesmith, of Los Angeles, report that their plans are complete. Frey says that as with last year's meeting, the program this year is geared to the needs of heavy industry in the Milwaukee area. In Los Angeles, the focus is on aircraft production.

Burt Monesmith and his committee are giving their program a new twist. In addition to laying out the subjects, they have laid out the bases to be touched under each of the 12 topics selected. For example, in the session on tooling economics they are going to cover:

- How to keep down costs on prototype tooling,
- What type tooling to use for short-run production,
- When to use optics and masters and how their cost compares with other methods,
- Evaluation of tools as to break-even point based on quantity and rate of production,
- How to estimate cost of tools and how to get and use new models,
- Objectives and current activities

in tool research and tooling methods,

- Training journeymen mechanics and toolmakers, and
- Measurement of tool shop performance through tool estimates.

In 1953 repeat performances of the Production Forum are scheduled for Milwaukee and Los Angeles. The Production Forum in Cleveland next March will be part of the SAE 1953 National Production Meeting. Paul Miller, of Leece-Neville, is carrying the ball as chairman of both the meeting and the Forum.

The Production Forum will hit New York for the first time next year, preceding the three-day SAE National Aeronautic Meeting. Dr. Michael Field, of Metcut Research Associates, has just accepted the general chairmanship of that Forum. The Forum scheduled for Toronto in the fall of '53 is appearing in that city for the first time too. It will be bossed by Col. Malcolm Jolley, of Canadian Acme Screw & Gear. This Forum will be a part of the SAE International Production Meeting.

The seeds planted by the SAE Production Activity in 1947 are bearing fruit. The Forum idea has been carefully cultivated and now has solid SAE roots. Now that it's spreading, a richer harvest is in store for SAE membership.

NOB HILL . . .

. . . site for 12-paper-and-dinner West Coast Meet in SF.

SAE National West Coast Meeting, scheduled for Aug. 11-13 at the Fairmont Hotel, high atop Nob Hill in San Francisco, will be reported in full in SAE Journal's October issue. (It's just too late to make September.)

Twelve technical papers at its sessions will reflect forward thinking in each of the areas covered by the sponsoring Activities: Transportation & Maintenance; Fuels & Lubricants; Truck & Bus, and Diesel.

W. G. Nostrand

Program Chairman Wayne Goodale, S.O. of California, reported all program details complete when he talked to the sponsoring Activity Committees which met during the Summer Meeting at Atlantic City.

On the first day of the meeting Ford's A. J. Pocock will present a paper under the provocative title: "Can Engine Wear Be Trapped in a Can?" He will show how engine wear can be counteracted effectively by using available equipment. His data are based on study of 50 engines and 845,082 miles of operation.

The meeting as a whole is under the leadership of Winslow Engineering's W. G. Nostrand as general chairman of the meeting—as well as 1952-1953 chairman of the Northern California Section. (Complete program with a very brief digest of each paper appeared in the July SAE Journal.)

NEW DATA . . .

. . . are promised on ever-current topics at September Tractor Meeting.

NEW data on ever-current topics are promised at the National Tractor Meeting next month (Milwaukee, Sept. 8-11). The Tractor Production Forum —new and very successful last year—will again be held on the day preceding the Tractor Meeting proper. (See "PRO DUCTION Goes!" on pages 72-74 of this issue.)

S. C. Heth

Dust and cleaners . . . winterization . . . and tire life . . . all are familiar subjects for discussion when tractor and implement engineers get together. But each year the results of fresh attacks on these perennial problems find expression at Milwaukee. And this year will be no exception, according to the final program developed by the Tractor & Farm Machinery Activity Committee and Tractor Vice-Chairman for Meetings S. C. Heth of J. I. Case.

Converters and Power Steering

Explored, too, will be tractor aspects of hydraulic torque converters . . . and power steering.

Fitting end for the four-day technical activities will be Goodyear President E. J. Thomas' address at the Thursday evening dinner . . . topped off by the always popular Milwaukee Section-sponsored golf party and dinner the next day at beautiful Tripoli Country Club.

International Harvester's Geo. W. Mork is general chairman for this year's meeting.

CHURCHILL . . .

. . . takes Meetings post to fill the unexpired term of E. H. Kelley.

HAROLD E. CHURCHILL has been named chairman of SAE's Meetings Committee for the remainder of 1952. He will fill the unexpired term of E. H. Kelley. Kelley, who has recently become general manufacturing manager of GMC's Chevrolet Division, resigned because he felt the duties of his new position would prevent his devoting the needed amount of time to it in coming months.

Active in Meetings

Churchill, director of research, Studebaker Corp., is currently SAE Vice-President representing Passenger Car Activity, and has had a wide experience in SAE meetings work. He has been active in meetings development both as Vice-Chairman for Meetings of Passenger Car Activity Committee and in the Chicago Section, of which he was chairman in 1948-49.

17 ATTEND . . .

. . . Diesel Engine Activity Committee to plan meetings far into 1953.

WITH 17 members in attendance, the Diesel Engine Activity Committee at Atlantic City on July 5 approved an 8-paper, 2-day program (plus a dinner) for its 1952 National Diesel Engine Meeting in St. Louis, Oct. 30 and 31. Then, with Meetings Vice-Chairman F. A. Robbins in the chair, they went on to outline two sessions for the 1953 Annual Meeting and give preliminary consideration to 1953 Summer Meeting plans.

The committee is thinking about new high output engines as a possible Annual Meeting topic . . . and is set on a symposium session dealing with instrumentation for engine cylinder pressures. Idea is to emphasize use of electronic instrumentation in diesels.

R. O. Slattery, general chairman of 1952 SAE National Diesel Engine Meeting

St. Louis Set as Host

General Chairman for this Fall's meeting is R. O. Slattery of Shell Oil in St. Louis. Although not present at the Atlantic City gathering, Slattery reported progress on dinner and dinner-speaker arrangements, which are being made by his St. Louis Section committee. Ray Tucker, Dean of Mechanical Engineering at Washington University is to be the toastmaster.

Arrangements have been completed to hold the **1953 National Diesel Engine Meeting** at the Hotel Knickerbocker in Chicago, Tuesday and Wednesday, Nov. 3-4, 1953. (A joint dinner will be held Nov. 4 with the National Fuels & Lubricants and National Transportation meetings, scheduled at the same place for Nov. 5 and 6 and Nov. 2-4, respectively.

KREML

Is 1952 Beecroft Lecturer

THE 1952 SAE Beecroft Memorial Award will be presented to Franklin M. Kreml during the annual meeting of the International Association of Chiefs of Police in Los Angeles on the evening of Sept. 24. SAE Past President James M. Crawford, chairman of the Award Committee, will make the presentation. Kreml is director of the Traffic Institute of Northwestern University and of the Traffic Division of the IACP.

Franklin M. Kreml

Kreml will present his 1952 Beecroft Lecture on the afternoon of Oct. 22 at the Congress Hotel in Chicago before the National Safety Congress. The lecture—sixth in a series of ten—will be published as a monograph by SAE and made available for widespread distribution along with the preceding Beecroft Memorial Lectures. Growing out of the terms of a $2,500 bequest of the late David Beecroft, President of SAE in 1921, the Award is made annually for "substantial contributions to the safety of traffic involving motor vehicles."

Recipients of previous awards were Paul G. Hoffman, president of Ford Foundation and former chairman of the Automotive Safety Foundation; Thomas H. MacDonald, U. S. Bureau of Public Roads; Chief Justice Arthur T. Vanderbilt, New Jersey Supreme Court; Sidney Williams, formerly assistant to the president, National Safety Council; and Rudolph F. King, registrar of motor vehicles of Massachusetts.

A native of Chicago, Kreml attended University of Wisconsin, Northwestern University and John Marshall Law School, receiving his L.L.B. degree from the latter institution. He was a police officer with the Evanston Police Department while attending Northwestern and worked his way through the ranks to lieutenant commanding traffic and director of the city's accident prevention bureau. He organized the bureau, the first of its kind in the country.

Kreml served overseas in World War II with the Army Transportation Corps and holds the rank of colonel in the organized reserve. He is a former chairman of the National Safety Council's Traffic and Transportation Conference, is vice-chairman of the Council's Board of Directors, and is secretary of the Committee on Enforcement of the President's Highway Safety Conference.

You'll Be Interested to Know . . .

Howard H. Dietrich, Rochester Products Division, GMC, has been appointed to the Diesel Engine Activity Committee by SAE Vice-President Walter Ainsley.

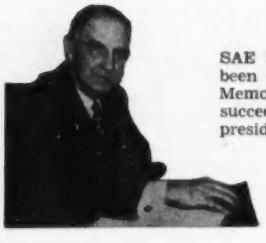
SAE will celebrate its 50th Anniversary in 1955.

A total of 2398 membership applications were received during the last Section year. Membership Chairman J. H. Booth told his Executive Committee at its last meeting. That total was the best in several years, he said.

Booth reported that, in the Activity area, the aircraft groups are showing increased strength, as might be expected under present conditions.

The Service Member and Foreign Member grades are likely to be written out of the SAE Constitution. Preliminary step was favorable SAE Council action on a recommendation of the Membership Committee. . . . Since SAE dues are now based entirely on age without reference to membership grade, these two grades, Council agreed, no longer have significant reason for existence.

An SAE tie-clasp is soon to be added to the list of jewelry for sale by the Society. Design of the new clasp was approved by the Membership Committee Executive Committee at its meeting in Atlantic City on June 3rd. The clasp will be available on the same basis as other SAE emblems—either by sales to individuals from SAE Headquarters or by shipment to Sections on consignment for resale to members. Price will be about $2.50.



SAE Past President J. M. Crawford has been appointed chairman of the Beecroft Memorial Award Committee. Crawford succeeds Robert F. Black, White Motor president, who resigned.

F & L . . .

. . . at Tulsa to go further on CC deposits, oil additives, and synthetic lubes.

THE 1952 edition of the National Fuels & Lubricants Meeting bids fair to be one of the best chapters yet in this long series. Mapped out at a Summer Meeting get-together of the F&L Activity Committee, this year's two-day confab returns to Tulsa. There, on Nov. 6-7, petroleum engineers and technologists will exchange and compare fresh data on problems old and new . . . and expound on new concepts.

Synthetic lubricants, combustion chamber deposits, precombustion reactions, and oil additives—these are just a few of the subjects they'll be discussing. And it's a pretty good bet that special military problems and engine wear won't be overlooked.

Altogether the program offers nine papers on nine different subjects—all hand-picked by the F&L Activity Committee and its Vice-Chairman for Meetings, F. A. Suess, of Continental Oil Co., who is also General Chairman of this meeting.

BRILLIANT...

. . . banquet will be SAE's part in Centennial of Engineering at Chicago.

MEMBERS and guests attending the SAE Banquet at the Centennial of Engineering will be richly rewarded, according to plans for the event completed by the 1952-53 Governing Board of the Chicago Section at its first meeting on July 1.

A sparkling and distinguished program has been developed by the General Committee with the cooperation of the Chicago Section. E. H. Kelley, past chairman of the SAE Meetings Committee and factory manager, Chevrolet Division, General Motors Corp., is chairman of the General Committee, and Robert C. Wallace, executive engineer, Diamond T Motor Car Co., is chairman of SAE Chicago Section.

The Banquet will be held Thursday, Sept. 4. 1952, at the Hotel Knickerbocker in Chicago. The SAE is one of 60 national and international engi-

Society of Automotive Engineers Banquet

at the

Centennial of Engineering

SAE Chicago Section—Host Hotel Knickerbocker Chicago

Thursday, September 4, 1952

6:15 p.m.—Reception—Champagne Room and Continental Club, Mezzanine Floor
7:00 p.m.—Banquet—Grand Ballroom

This Banquet represents the SAE's participation in the Centennial of Engineering celebration in which some 60 national and international engineering organizations will meet, in Chicago, from September 3 to 13, 1952. The Centennial of Engineering appropriately observes the 100th anniversary of the founding of the first national civilian society of engineers in the United States—the American Society of Civil Engineers.

Program

Welcome	**ROBERT C. WALLACE**, Chairman, SAE Chicago Section
Toastmaster	**R. J. S. PIGOTT**, SAE Past-President and President, American Society of Mechanical Engineers
SAE President	**D. P. BARNARD**
Honorary Chairman	**C. F. KETTERING**, SAE Past-President and Chairman, Executive Committee, Centennial of Engineering
PRINCIPAL SPEAKER	**S. W. SPARROW**, SAE Past-President and Vice-President of engineering, Studebaker Corp.
	"Years, Ideas, and Engineers"

Tickets—$5.00 each

Mail your applications to: **Floyd E. Ertsman**
Chicago Section—SAE
1420 Fisher Building
343 South Dearborn St.
Chicago 4, Illinois

Applications must be received by August 18

neering organizations that will hold meetings in Chicago from September 3 to 13 to celebrate the Centennial of Engineering. The Centennial marks the 100th Anniversary of the founding of the first national civilian engineering society in the United States—the American Society of Civil Engineers.

The Banquet program will dramatize the contributions made by automotive engineers to a century of engineering progress. It is designed to inform, inspire, and entertain: (See program at top of this page.)

An added feature will be the presentation of a scroll to the American Society of Civil Engineers by SAE President D. P. Barnard in honor of the ASCE's 100th Birthday.

An unusually distinguished list will be invited as honor guests at the Speakers' Table. The list includes SAE's founder members, the presidents, and secretaries of national and international societies whose interests are related closely to those of the SAE; SAE past-presidents; and SAE Council members.

Extra attractions not listed on the program include:

- A general reception starting at 6:15 p.m. immediately preceding the Banquet contributed by the host—the SAE Chicago Section;
- Appropriate music during the reception and banquet;
- Attractive souvenir programs and seating lists will be placed at each plate to serve as mementos of the occasion.

Every effort is being made to make this Banquet the most distinguished and enjoyable event of its type that the SAE has ever held.

Robert C. Wallace

Reunion at Uniontown

By Mrs. Walter G. Ainsley

1952

At the "Uniontown Reunion" on June 7, 1952, the following were in attendance:

Mr. & Mrs. Walter Ainsley
Mr. & Mrs. L. E. Baker
Mr. & Mrs. D. P. Barnard
Mr. & Mrs. Earl Bartholomew
Mr. & Mrs. H. W. Best
Mr. & Mrs. T. A. Boyd
Mr. & Mrs. A. L. Clayden
H. K. Cummings
Mr. & Mrs. C. D. Hawley
L. E. Hebl
Mr. & Mrs. W. M. Holaday
Mr. & Mrs. K. L. Hollister
Mr. & Mrs. Leo Huff
Mr. & Mrs. C. B. Kass
Mr. & Mrs. B. A. Kulason
Mr. & Mrs. G. J. Liddell
J. B. Macauley
J. R. MacGregor
Robert Mescher
Mr. & Mrs. E. B. Phillips
Mr. & Mrs. Leonard Raymond
Mr. & Mrs. T. B. Rendel
Mr. & Mrs. J. R. Sabina
Mr. & Mrs. J. P. Stewart
H. M. Trimble
Mr. & Mrs. C. B. Veal
Mr. & Mrs. Cleveland Walcutt
Genevieve Walmsley
J. A. C. Warner
Mr. & Mrs. Gilbert Way
A. B. Wilder

1952—Reunion

TWENTY years ago the Detonation Subcommittee of the Cooperative Fuel Research group met to develop a cooperative road test program. Their pioneering work at Uniontown, Pa., on comparing antiknock road performance of fuels on the road sparked big gains in the automotive and petroleum industries. June 7, 1952, the men in this original group and their wives again gathered at Uniontown to commemorate their cooperative venture.

All Had Fun

And they "commemorated" by renewing warm friendships and gossiping of now and then. . . . It was the unanimous opinion of all the reunioners, that Jack Sabina had weathered the years with the least deterioration. . . . John Campbell, absent to attend his son's graduation from Bowdoin College, was represented by a gift libation to the party held in the Baron Munchausen Room. His gift was poured into a loving cup, ice and soda was added, and everyone shared. . . . Genevieve Walmsley, off to Europe shortly after the reunion, wore a dress which no couturier could surpass. . . . Dorothy Veal opined that the chief reason for the reunion was to form the "Club of Expectant Grandmothers" . . . and "The Man on the Flying Trapeze" was the theme song still—as it was in the beginning.

The reunioners recalled old times and remembered some of the trials and tribulations in launching their program. Some one dragged out a clipping of an article written by Arch Foster in National Petroleum News, July 18, 1934. It said, in part:

"In 1934 forty men and fifteen 1934 model cars, representing four countries, held the second series of motor fuel tests. (God knows what happened to the first series.) They represented the most experienced and highly trained group of men in the world on this problem.

"The purpose of the program was to compare road performance of a series of typical fuels, as regards their antiknock qualities, as shown on the road in different cars, and to determine if the results found by laboratory testing these fuels by the so-called Motor Method of knock testing agrees with road performance of the fuels. Every interested company has been invited repeatedly to participate in the tests, and the writer was surprised to see so few oil companies represented. Probably the pleasantest and most

promising feature of the meet is the international character it takes on, with four countries cooperating."

Most of the men who were behind the original program are still active in SAE circles. For example, Tad Boyd was chairman of the Detonation Subcommittee. "Skipper" Veal was secretary of the CFR committee. Jack Sabina selected the Uniontown Hill as the test site. (He said the long, continuous grade gave operators a chance to drive cars with wide-open throttle to evaluate fuels under the most severe knocking conditions.)

John Campbell, Bill Holaday, and Herb Best made up the coordinating group. And it was Ludlow Clayden who had recommended the cooperative road test program.

Quotable Quotes

When asked at the Uniontown reunion what they thought about the original meeting, here is what some of the men said:

"Skipper" Veal: The men I met for the first time on the porch of the Summit Hotel have influenced the trend in their companies ever since. Their impact on fuel research was comparable to "the shot heard 'round the world." The only difference I can see now is that it takes the same men 30 min and three drinks to reach the same level it used to take 2 hr to attain.

Ludlow Clayden: The purpose of the program was to clarify the relationship between engine design and gasoline consumption. It established a method of testing cars and fuels which has developed into a series of standard methods which have made possible the development of better cars and better gasolines.

Dan Barnard: Twenty years can see much progress when men work together. It is, therefore, inevitable that a group of alert, imaginative, technical men—thrown together to solve a technical problem—should produce information which would furnish an important part of the know-how back of the modern high compression engine.

John Warner: The most precious thing that can come from such a technical enterprise is friendship, understanding, and affection. These are bound to be the major ingredients when men of good will get together. Some may have thought that the major results of the road tests would be the engineering discoveries. These were indeed important. Actually, though, the most important results were the enduring friendships.

Herb Best: Men of different opinions cooperate, get along, and produce a method of rating which has had a world-wide effect on both industries.

Bill Holaday: No other project has had as profound an effect on engine design.

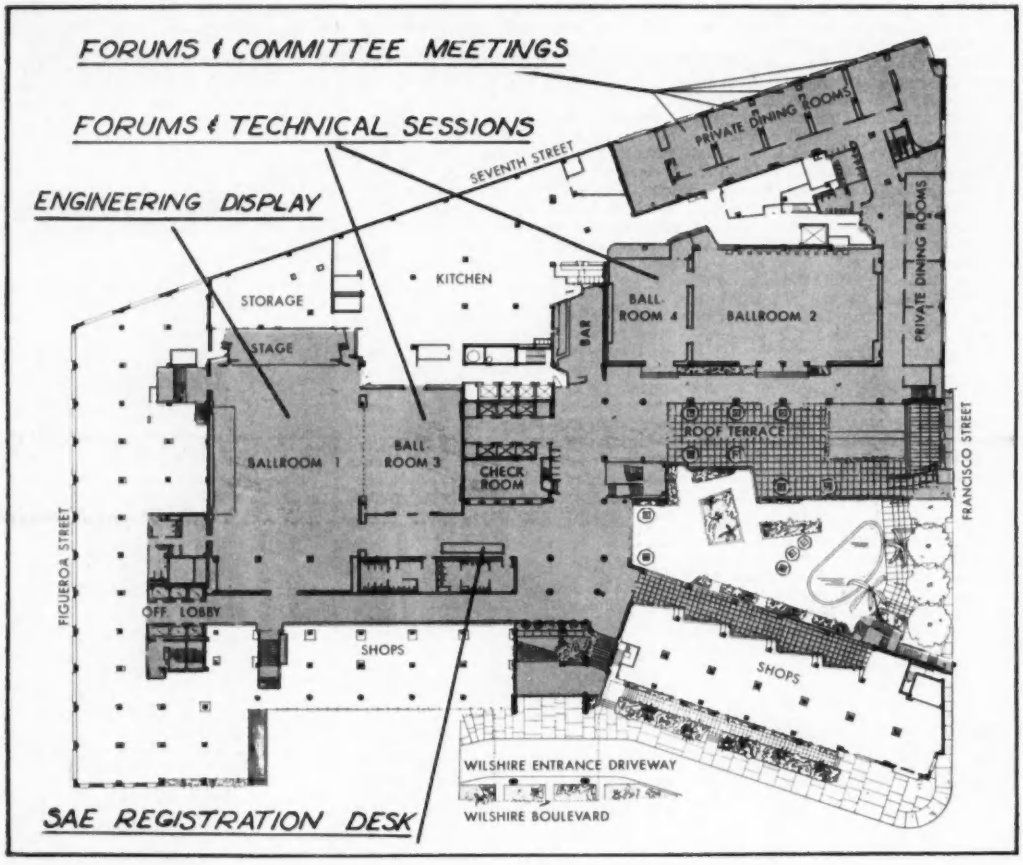
Walter Ainsley: The program of cooperative research, as initiated at Uniontown, set up a procedure which was used by the Army in World War II for solving fuels and lubricants problems.

1932

At the Waukesha meeting following the first Uniontown tests in 1932 were:

Walter Ainsley
L. E. Baker
W. E. Beall
A. E. Becker
H. W. Best
T. A. Boyd
John M. Campbell
A. L. Clayden
H. K. Cummings
J. E. DeLong
Graham Edgar
J. B. Fisher
Mrs. Freckman
W. M. Holaday
K. L. Hollister
G. A. Hope
H. L. Horning
W. H. Hubner
Leo Huff
J. R. MacGregor
S. P. Marley
Neil MacCoull
K. R. Meyer
W. S. Mount
E. B. Phillips
T. B. Rendel
E. R. Rutenber
G. C. Rodgers
J. R. Sabina
Taylor Stanton
J. P. Stewart
C. B. Veal
Cleveland Walcutt
N. R. White
H. M. Wiles
K. T. Winslow

1932-After 1st Meeting

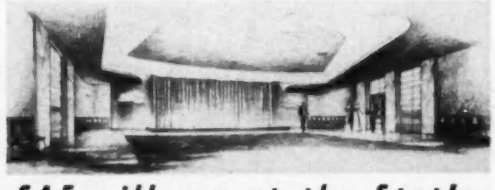


1952 Los Angeles Aero Meeting

ABOVE is the plan of the ballroom floor of the new Statler Hotel in Los Angeles, site of the SAE National Aeronautic Meeting, Production Forum and Engineering Display, October 1–4.

The SAE gathering will be one of the first to be held in this great new hostelry. Facilities will be fully completed to house what promises to be SAE's greatest aeronautic gathering to date.

The meeting will use most of the facilities on this big ballroom floor. The Engineering Display will be held in the big Ballroom 1 during the week; the Grand Ball on the closing night. Regular technical sessions will be in Ballrooms 3 and 4. Production Forum sessions will use Ballrooms 3 and 4 and some of the private dining rooms. Committee meetings will be held in the private dining rooms.



Here is one of the new Ballrooms SAE will use at the Statler during the 1952 Aeronautic Meeting.

RUSSIA'S . . .

. . . air arsenal is to be topic at closed session of LA Aero Meeting.

SAE members who want to hear about Russia's air arsenal had better fill out promptly the request-for-clearance forms which have been mailed to them prior to the program of the SAE West Coast Aeronautic Meeting . . . and get them endorsed by company and military security officers.

The paper "Soviet Air Weapons" is to be given at the LA gathering by Fred Kobernuss of the Air Technical Intelligence Center, Wright-Patterson Air Force Base on Thursday evening, Oct. 2, in Los Angeles' Statler. At the same session Ralph Bayless of Convair will discuss "Flight Experience with Delta Wing Aircraft" and J. A. O'Malley, Jr., and R. J. Woods of Bell will present "Design Features of the Bell X5 With Adjustable Wings." A. L. "Maj" Klein is session chairman.

"Confidential" Clearance Needed

Security regulations require that attendance at this session be limited to citizens of the United States who possess evidence of current clearance through "Confidential." Each SAE member has been sent two request-for-clearance blanks. Applicants should fill out both blanks and submit them to company and military security officers as explained on the blanks.

To applicants cleared by the Air Force, SAE will send an admission certificate similar to that used for the Summer Meeting Confidential session. Those who do not qualify will also be notified.

SAE members Albert E. Lombard, Jr., James D. Redding, W. C. Heath, and F. W. Fink, have been working with Air Force security officials on the clearance arrangements.

Besides the confidential session, there will be 10 open sessions at the West Coast Aeronautic Meeting. Sessions include three symposia and nearly a score of papers. The Meeting begins Thursday, Oct. 2—following the Aircraft Production Forum on Oct. 1—and runs to Saturday noon, Oct. 4.

JIM REDDING helped arrange for the paper on Russia's aircraft

CALENDAR

National Meetings

Meeting	Date	Hotel
1952		
WEST COAST	Aug. 11-13	Fairmont, San Francisco
CENTENNIAL of ENGINEERING BANQUET	Sept. 4	Hotel Knickerbocker, Chicago
TRACTOR and PRODUCTION FORUM	Sept. 8-11	Schroeder, Milwaukee
AERONAUTIC, AIRCRAFT ENGINEERING DISPLAY, and PRODUCTION FORUM	Oct. 1-4	Statler, Los Angeles
TRANSPORTATION	Oct. 22-24	William Penn, Pittsburgh
DIESEL ENGINE	Oct. 30-31	Chase, St. Louis, Mo.
FUELS and LUBRICANTS	Nov. 6-7	The Mayo, Tulsa
1953		
ANNUAL MEETING and ENGINEERING DISPLAY	Jan. 12-16	The Sheraton-Cadillac, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 3-5	The Sheraton-Cadillac, Detroit
PRODUCTION	March 25-27	Statler, Cleveland
AERONAUTIC and AIRCRAFT ENGINEERING DISPLAY and AIRCRAFT PRODUCTION FORUM	April 20-24	Hotel Governor Clinton, New York City
SUMMER	June 7-12	The Ambassador and Ritz-Carlton, Atlantic City, N. J.
INTERNATIONAL WEST COAST	Aug. 17-19	Georgia Hotel, Vancouver, B. C.
TRACTOR and PRODUCTION FORUM	Sept. 14-17	Hotel Schroeder, Milwaukee

1952 SAE National

Monday, September 8

PRODUCTION FORUM

Sponsored by SAE Production Activity
Chairman—**M. L. FREY**, Allis-Chalmers Mfg. Co.

10:00 a.m. to 12:00 Noon
2:00 p.m. to 4:00 p.m.

Six separate informal gatherings to exchange information and experience on vital production problems. Each will be sparked by a panel of experts as shown.

FORGING Parlor B (4th Floor)

Panel Leader
E. O. DIXON, Ladish Co.

Panel Secretary
L. L. BOWER, Waukesha Motor Co.

Panel Members
GEORGE DASCHKE, Packard Motor Car Co.
R. J. EXTER, Wyman-Gordon Co.
R. L. MATTSON, General Motors Corp.
C. E. STONE, Interstate Drop Forge Co.
A. R. NETTENSTROM, American Brake Shoe Co.

***GEARS**

10:00 a.m.—Parlor C. (4th Floor)
2:00 p.m.—East Room (5th Floor)

Panel Leader
B. W. KEESE, Wisconsin Axle Division, Timken-Detroit Axle Co.

Panel Secretary
M. BARKER, Kearney and Trecker Corp.

Panel Members
A. S. BLACK, Fellows Gear Shaper Co.
FRED BOHLE, Illinois Tool Works
F. H. BOOR, Wisconsin Axle Division, Timken-Detroit Axle Co.
IGOR KAMLUKIN, Allis-Chalmers Manufacturing Co.
F. E. McMULLEN, Gleason Works
N. T. NILSON, International Harvester Co.
CHARLES STAUB, Michigan Tool Co.
J. C. STRAUB, American Wheelabrator and Equipment Corp.
L. A. BIXBY, Management and Engineering Consultant
F. L. KNOWLES, Gleason Works

***HEAT TREATING**

10:00 a. m. Parlor D (4th Floor)
2:00 p.m. East Room (5th Floor)

Panel Leader
J. E. SCHOEN, Marquette University

Panel Secretary
R. ULICHNEY, Ladish Co.

Panel Members
WALTER HOLCROFT, Holcroft and Co.
L. W. STEEGE, John Deere Waterloo Tractor Works
J. H. CLARK, International Harvester Co.
C. I. WESLEY, Wesley Heat Treating Co.
L. E. WEBB, Clarke Equipment Co.
T. A. FRISCHMAN, Eaton Manufacturing Co.

QUALITY CONTROL
Pere Marquette Room (5th Floor)

Panel Leader
H. A. WEISSBRODT, International Harvester Co.

Panel Secretary
I. W. SCHOENINGER, Globe-Union Inc.

Panel Members
J. N. BERRETTONI, Dr. J. N. Berrettoni & Associates
E. L. FAY, Deere and Co.
E. R. MEYER, Eureka Williams Corp.
W. H SMITH, Ford Motor Co.

MATERIALS HANDLING
Parlor A (4th Floor)

Panel Leader
M. A. TRAVIS, Nash Body Division, Nash-Kelvinator Corp.

Panel Secretary
F. D. GUNDERSON, Le Roi Co.

Panel Members
F. M. BLUM, Harnischfeger Corp.
EMMITT JOHNSON, International Harvester Co.
B. I. ULINSKI, Automatic Transportation Co.
J. C. WEBB, Jervis B. Webb Co.
R. F. WEBER, International Harvester Co.

* The Gear and Heat Treating Panels will meet separately in the morning, and will meet jointly in the East Room in the afternoon to discuss the common problem of the heat treatment of gears.

WELDING Parlor E (4th Floor)

Panel Leader
J. J. CHYLE, A. O. Smith Corp.

Panel Secretary
H. HAMMER, Perfex Corp.

Panel Members
I. R. BARTTER, Lincoln Electric Co.
C. D. EVANS, International Harvester Co.
KENNETH JACKSON, Caterpillar Tractor Co.
E. D. MORRIS, Linde Air Products Co.
WILLARD SCHUMBACHER, Allis-Chalmers Manufacturing Co.
EMERY JONES, Precision Welder Co.
B. O. JOSLIN, John Deere Van Brunt Co.

Tuesday, September 9

9:30 a.m. Ballroom

Welcome to Milwaukee
R. K. McCONKEY
Chairman, SAE Milwaukee Section

Chairman—**D. W. ERSKINE**, Allis-Chalmers Manufacturing Co.
Secretary—**L. W. NELSON**

The Hydraulic Torque Converter—Its Effect on Power Trains
R. M. SCHAEFER, Allison Division, General Motors Corp.

Tire Life in Off Highway Service
L. W. FOX, Firestone Tire and Rubber Co.

(Sponsored by Construction and Industrial Machinery Subcommittee)

1:30 p.m. Ballroom

Chairman—**M. R. BENNETT**, International Harvester Co.
Secretary—**L. W. NELSON**

Logging with Tractors—Equipment, Logging Arch and Winches
H. F. WAHL, Hyster Co.

Starting Cold Diesels
D. E. KILTY, **N. K. LAMMERS** and **K. J. FLECK**, Caterpillar Tractor Co.

Tractor Meeting and Production Forum

Sept. 8–11, Hotel Schroeder, Milwaukee

Airborne Construction Equipment
R. G. ALEXANDER, Research and Development Laboratories, Engineer Corps, Fort Belvoir

(Sponsored by Construction and Industrial Machinery Subcommittee)

Wednesday, September 10

9:30 a.m. Ballroom

Chairman—**C. T. O'HARROW**, Allis-Chalmers Manufacturing Co.
Secretary—**D. F. SEMLAK**, Allis-Chalmers Manufacturing Co.

SYMPOSIUM — Progress in Engine Protection by Air Cleaning

The Effect of Dust on Engine Wear
E. S. DAHL, Massey-Harris Co.

Advantages of a Well Chosen Air Cleaner Inlet System
R. E. LARSON and **R. H. DONALDSON**, Donaldson Co., Inc.

New Methods of Securing Improved Air Cleaner Efficiency
D. P. EASTMAN, United Specialties Co.

(Sponsored by Tractor and Farm Machinery Subcommittee)

1:30 p. m. Ballroom

Chairman—**F. W. DUFFEE**, University of Wisconsin
Secretary—**GORDON BARRINGTON**, University of Wisconsin

The Influence of Speed on the Performance Characteristics of Implements
E. G. McKIBBEN and **I. F. REED**, Division of Agricultural Engineering Research, USDA

(Sponsored by Implement Subcommittee)

The Role of Castings in the Agricultural Industry
W. G. GUDE, Foundry, Penton Publishing Co.

(Sponsored by Engineering Materials Activity)

Thursday, September 11

9:30 a. m. Ballroom

Chairman—**S. C. HETH**, J. I. Case Co.
Secretary—**M. H. RIRIE**, J. I. Case Co.

A Review of Mechanical Harvesters for Sugar Cane
A. G. KELLER, Department of Chemical Engineering, Louisiana State University

The Mechanical Harvesting and Loading of Clean Fresh Sugar Cane in Louisiana
B. C. THOMSON, Thomson Machinery Co., Inc.

(Sponsored by Implement Subcommittee)

1:30 p. m. Ballroom

Chairman—**MERLIN HANSEN**, John Deere Waterloo Tractor Works
Secretary—**IGOR KAMLUKIN**, Allis-Chalmers Manufacturing Co.

Another Look at the Scoring Phenomena of Gears
B. W. KELLEY, Caterpillar Tractor Co.

Factors Affecting the Efficiency of Farm Tractors
C. W. SMITH and **L. F. LARSEN**, University of Nebraska

Possibilities of Power Steering for Farm Tractors
F. M. ISON, Saginaw Steering Gear Division, General Motors Corp.

(Sponsored by Tractor and Farm Machinery Subcommittee)

DINNER

7:00 p. m. Ballroom

C. A. HUBERT, Chairman

F. M. POTGIETER, Toastmaster

D. P. BARNARD, SAE President

Principal Speaker

E. J. THOMAS
President, Goodyear Tire and Rubber Co.

About

ROBERT M. CRITCHFIELD has been named general manager of GMC's Pontiac Motor Division. Assistant general manager of the Allison Division since January, 1951, Critchfield was previously factory manager of the Delco-Remy Division, after having been its chief engineer. . . . He is an electrical engineer, a graduate of Ohio State University '16, and started his business life with Westinghouse Electric & Manufacturing Co. . . . A member of SAE since 1920, Critchfield has played an important part in SAE technical committee work and in 1937–38 was chairman of the Indiana Section. . . . He succeeds the late **ARNOLD LENZ**, who was killed in an automobile accident on July 13. (See p. 90)

WILLIAM A. McKINLEY has been elected president of Midland Steel Products Co., Detroit. McKinley has been with the company for 27 years, serving as head of the engineering department, vice-president in charge of sales and most recently as executive vice-president.

BURT C. MONESMITH recently was promoted from manufacturing manager to vice-president and manufacturing manager of Lockheed Aircraft Corp. He has been with Lockheed since 1946. Before that, he was in charge of all factory operations at Douglas Aircraft's Tulsa plant. Monesmith was general chairman of the 1951 SAE Production Forum in Los Angeles and is again heading up this year's Forum in Los Angeles.

ALEXANDER R. LINDSAY, who has been chief engineer of the automotive division of the Budd Co., has been named vice-president in charge of research. He succeeds retiring Vice-President **G. M. BARNES**. Lindsay moves to Philadelphia from Detroit, where he has served with the Budd automotive division since 1937.

RICHARD E. BROWN has been named chief engineer of Air-Maze Corp., Cleveland, Ohio. Brown has been with Air-Maze for the past ten years as development engineer and, more recently, assistant chief engineer. He is a graduate of Case Institute of Technology and a member of Beta Theta Pi.

HANS A. MATTHIAS has been named executive engineer, passenger vehicles design, on the engineering staff of Ford Motor Co. He was previously assistant chassis engineer for Lincoln-Mercury Division. Matthias is also a member of the engineering staff's policy-making Engineering Board. Newly appointed to the Engineering Board are **HENRY C. GREBE**, executive engineer, body engineering office, and **VICTOR G. RAVIOLO**, executive engineer, engine engineering office.

WILLIAM G. LAFFER now has the title of vice-president in charge of operations of the original equipment division of the Cleveland Graphite Bronze Co. Laffer joined the company in 1927 after graduating from Yale. He became works manager in 1946 and vice-president in charge of manufacturing in 1948. During World War II he served with the War Production Board for two years, coordinating the production of aircraft engine bearings.

GEORGE O. NOVILLE, president of G. O. Noville and Associates, Los Angeles, has announced the merging of Noville with Larad Engineers, Culver City, Calif. **SAMUEL L. SOLA**, who was engineering manager of Larad, is now secretary of the combined company, which continues under the name of G. O. Noville and Associates, Inc.

B. A. LINDNER is now chief engineer of the Arlington, Texas, plant of Buick - Oldsmobile - Pontiac Assembly Division. Lindner was previously representative for Fairchild Aircraft at the Kaiser-Frazer plant in Willow Run, Mich.

HUGH S. HIGHET has been named chief manufacturing consultant for Cleveland Graphite Bronze Co. Highet, born in Scotland, came to this country in 1923 and joined Cleveland Graphite Bronze in 1927. He has been general superintendent of the company since 1946. Highet is a member of SAE's Production Activity Committee.

Members

JOHN M. CAMPBELL (left) has been named assistant technical director on the staff of **CHARLES L. McCUEN**, General Motors vice-president and general manager of GM Research Laboratories. Succeeding Campbell as head of the organic chemistry department is **DR. LLOYD L. WITHROW** (right), who was formerly Campbell's assistant. Campbell has been head of organic chemistry for the Laboratories since 1947. During World War II, he served on the War Advisory Committee of CRC. Dr. Withrow, who has been with GM since 1926, was winner of SAE's Horning Memorial Award in 1939.

DAVID F. TOOT has been appointed assistant to **F. W. SLACK**, chief engineer of chassis design in the engineering division of Chrysler Corp. Toot was previously supervisor of the division's special mechanical design department. He has been with Chrysler since 1934.

JOHN K. NORTHROP, president of Northrop Aircraft, Inc., was guest speaker at a dinner at Lockheed Aircraft Corp. in honor of Lockheed employees who have been with the company since 1932, when the company was taken over by the present management. The Northrop president got his start at Lockheed, going on to found the company that bears his name.

RALPH E. WILLIAMS has been appointed director of purchases of National Pneumatic Co., Inc., and Holtzer-Cabot Division, Boston, Mass. Williams was previously production control manager and chief inspector for National Pneumatic. Prior to that, he was sales engineer at the Detroit office of McQuay-Norris.

FREDERICK C. WEYBURNE, general manager of Bendix Aviation's Marshall-Eclipse Division, has been elected vice-president of the Friction Materials Standards Institute for 1952-53. SAE members among the directors of the Institute are **G. E. RITTER** of the Molded Materials Division of Carlisle Corp. and **D. H. SPICER**, president of World Bestos Corp.

ANTONIO FESSIA of Milan made a flying visit to New York to attend the June 12-14 meetings of the International Organization for Standardization at Columbia University, returning to Milan on June 18 to preside over examinations at the Polytechnical Institute. In a visit to SAE headquarters, Professor Fessia extended greetings to SAE from the Associazione Tecnica Automobile of Italy, of which he is executive vice-president.

CARL SAAL has been made head of the newly-created vehicles operation section, of the Bureau of Public Roads. **HOY STEVENS**, formerly with American Trucking Associations, will serve on Saal's staff, heading up the transportation economic unit and devoting his time to the size and weight problem. Saal has been researching brake and vehicle characteristics at the Bureau since 1940. Stevens, a past chairman of the SAE Washington Section, has been with the ATA equipment and maintenance committee since 1946.

EDWARD C. HOENICKE, general manager of the foundry division of Eaton Mfg. Co., has been elected president of the Grey Iron Research Institute in Columbus, Ohio.

RAYMOND Z. OSWALD has been named president of Clevite Service, Inc., a new subsidiary of Cleveland Graphite Bronze Co. which will take over the business of Cleveland Graphite's replacement sales division. Oswald has until now been vice-president in charge of replacement sales for the parent company. **ALBERT M. CURRIER, JR.**, is general sales manager of Clevite. He previously held the same title with the replacement sales division of Cleveland Graphite.

JOHN B. O'CONNOR has been named vice-president and manager of new product development for Illinois Tool Works, Chicago. O'Connor was previously manager of new product development for Shakeproof, Inc., a division of Illinois Tool Works.

MARTIN E. KARP has been named chief engineer of Yankee Metal Products Corp. of Norwalk, Conn. Karp was previously head of research and development for the door control division of National Pneumatic Co. During World War II, he served as a Navy officer.

Thorne heads GMC Vehicle Development Group

M. A. Thorne

MAURICE A. THORNE has been named engineer in charge of General Motors engineering staff's vehicle development group. The appointment marks the consolidation of the automotive ordnance group, which Thorne has headed since 1941, and the car development group, previously directed by the late **LOUIS THOMS.** Thorne will be assisted by **R. V. HUTCHINSON** in the automotive ordnance section of the new group, and by **G. C. R. KUIPER** in the car development section.

Thorne has been with GMC since 1934, joining the company's Oldsmobile Division after serving Studebaker and Pierce-Arrow. Hutchinson, who came to General Motors Research in 1919, has been assistant head of the automotive ordnance group since 1941. Kuiper recently returned from Melbourne, Australia, where he had been assistant chief engineer at General Motors Holden's, Ltd., since 1945. He joined General Motors Overseas in 1937.

R. V. Hutchinson

G. C. R. Kuiper

LEWIS C. KIBBEE has been promoted to chief of the equipment and operations section of American Trucking Associations, Washington, D. C. He was previously assistant chief of the section. Kibbee joined ATA in 1949 after having served as experimental engineer for Mack Mfg. Co. During World War II, he served with the U. S. Marine Corps.

NEIL P. PETERSEN, president of Canadian Acme Screw & Gear, Ltd., Toronto, sailed last month for Europe. He and his wife are planning an extensive visit to Denmark, England, and Scotland. Petersen is a past chairman of SAE's Canadian Section and has served as an SAE councilor.

CHARLES H. KUTHE has been named manager of technical sales for Wolverine Tube Division of Calumet and Hecla Consolidated Copper Co. He will head the newly-formed technical sales unit, with headquarters in Detroit. Kuthe was formerly manager of the product development department for Wolverine.

R. H. GARDNER has been promoted to the newly-created post of research associate with Sinclair Oil Corp. at the research laboratories in Harvey, Ill. He was previously director of the lubricants division. Gardner's new position will permit him to devote all his time to research projects.

F. CLAYTON MESERVE, who was formerly chief engineer of MacMillan Oil Co. of Boston, Somerville, Mass., is now partner and chief engineer of Beco Associates, North Andover, Mass.

DAVID L. BERRY was one of two engineers that drove the winning car —a greatly modified 1924 Chevrolet— in the 1952 Shell Mileage Marathon, held at Wood River, Ill. These engineers made many changes in their car and its engine, sacrificing both performance and comfort, to set the record of 168.4 mpg. They also used special driving techniques designed to extract the last possible bit of energy out of the gasoline. A detailed account of the sort of changes that are necessary to attain such phenomenal mileages was given several years ago by **R. J. GREENSHIELDS**, who got 150 mpg in the 1949 Marathon. (See **SAE Journal**, March, 1950, pp. 34-38.)

FRED A. SAWYER has been named assistant development manager of United States Rubber Co.'s footwear and general products division. Sawyer was previously manager of automotive sales for the division. Later this fall he will move his headquarters from Detroit to the company's plant in Mishawaka, Ind.

LELAND E. COPPLE is now manager of the construction and mining equpiment department of Sterling Division of White Motor Co., Milwaukee, Wis. Copple was previously with Firestone Tire and Rubber Co.

ROBERT A. MONTGOMERY is now automotive engineer in the research and development division, tank-automotive branch, of the Army's Office of the Chief of Ordnance, Washington, D. C. He was previously chief of the specifications and procurement unit, wheeled vehicles.

HARVEY S. FIRESTONE, JR., has been awarded the Grand Band of the Order of the Star of Africa, highest honor given by the Republic of Liberia, in recognition of the "salutary and beneficial effect" that Firestone Tire and Rubber Co.'s activities have had on the country. Firestone was the first American company to go into the West African republic, beginning its development of rubber plantations there in 1926.

SAE members made up three-fourths of a panel on "Cornell's Role in the Future of Aviation" at the 1952 reunion at Cornell University. They were **DR. THEODORE P. WRIGHT**, Cornell's vice-president for research, **J. CARLTON WARD**, chairman of Thompson Industries, Inc., and **WILLIAM LITTLEWOOD** of American Airlines and the NACA.

MOHAMED M. EL-WAKIL, who has been a research associate at the University of Wisconsin, is now a lecturer at Farouk University in Alexandria, Egypt.

BILL TOBOLDT, editor of Motor Service Magazine, tells how to "Fix Your Ford" in his latest book. Published by Goodheart-Willcox, it describes repair short cuts and tells how to get better than normal speed, power, and economy from Fords dating back to 1932.

Toboldt has styled the book to be of special value not only to the average car owner who wishes to do an occasional job on his Ford . . . but also to the experienced mechanic who wants to do a better job in less time.

ROY C. INGERSOLL, president of Borg-Warner Corp., has announced the purchase of Reflectal Corp. by Borg-Warner. Reflectal, with a plant at Hudson Falls, N. Y., and offices in New York City, will be operated as a Borg-Warner subsidiary.

T. M. FAHNESTOCK has returned to his post of manager of the service engineering division of Caterpillar Tractor Co. after having served with the U. S. Corps of Engineers in Germany.

WALTER E. BENJAMIN has been named director of research and development engineering for Pierce Governor Co., Inc., Anderson, Ind. Benjamin, who was previously special project engineer for Pierce Governor, has been with the company for 24 years.

DR. RICCARDO CASIRAGHI is now general sales manager for Piaggio & C. S. p. A., Genoa, Italy. Dr. Casiraghi was previously at the Piaggio factory at Pontedera.

L. R. BARR has been named assistant general manager of Romec Division of Lear, Inc., Elyria, Ohio. Barr was previously chief engineer for the division.

R. D. PINKERTON has been named research associate at Sinclair Research Laboratories, Inc., Harvey, Ill. Pinkerton was previously director of light oils for the Laboratories. In his new post, he will devote all his time to research. Pinkerton joined Sinclair as a part-time employee in 1930 during his summer vacation from the University of Illinois, from which he graduated in 1932.

GEORGE C. BRADLEY is now general manager of Home Oil Distributors, Ltd., Vancouver, B. C. Bradley was formerly assistant general manager of the marketing department of Imperial Oil, Ltd., in Toronto.

FRANK W. FINK, chief engineer of Consolidated Vultee Aircraft Co., is a very active member of the Advisory Board on Curriculum of San Diego State College in San Diego.

JOHN K. NORTHROP, president of Northrop Aircraft, Inc., has announced the casting of a 16-foot magnesium airplane wing section. The wing section, believed to be the largest cast aircraft surface ever produced, is part of a research project sponsored by the U. S. Air Force to produce cast magnesium wings.

CARL J. STRID has joined Rhodes Lewis Co., Los Angeles, Calif., as project engineer on automotive accessories. He was formerly divisional engineer for General Controls Co., Glendale, Calif. Strid is a member of SAE Subcommittee A6, Aircraft Hydraulic and Pneumatic Equipment.

ROBERT S. BURNETT, for many years manager of the SAE Standards Department and editor of the SAE Handbook, retired last month. Under his aegis the Handbook grew from loose-leaf pocket size to its present proportions. He also served as secretary of many technical committees. Bob Burnett first came to SAE in 1917 as assistant to the standards manager. Within a few years he became standards manager, the title he carried until his retirement. Before coming to SAE he was an electrical engineer for several automotive and railway electrical equipment companies. He received his engineering education from Pratt Institute.

WILLIAM J. CARRY has been elected president and a director of General Laboratory Associates, Inc., Norwich, N. Y. Carry was previously vice-president of B-G Corp., and prior to that was associated with Fairchild Airplane and Engine Corp. and Wright Aeronautical Corp. During World War II he served as a commander in the U. S. Navy Bureau of Aeronautics.

R. JAMISON WILLIAMS, vice-president in charge of development engineering of American Metal Products Co., Detroit, has been elected a member of the board of directors of the company. Williams came to American Metal Products from the Budd Co. in 1935, becoming vice-president in 1948. He is a member of the SAE Subcommittee on Automotive Seating.

DONALD P. HEATH is now chief of the aviation fuels branch of the refining division of Petroleum Administration for Defense. He is on leave from Socony Vacuum's research and development laboratories at Paulsboro, N. J., where he is research associate. Heath was previously with PAD briefly in 1950, and was a member of PAD's military fuels technical advisory committee.

ROBERT D. OLDFIELD, JR., has been named sales manager of Ohio Screw Products, Inc., Elyria, Ohio. Oldfield was previously with Johnson Bronze Co., New Castle, Pa., as sales engineer.

Hurley Receives Airpower Trophy

ROY T. HURLEY (center), chairman and president of Curtiss-Wright Corp., was awarded the 1952 Airpower Trophy by the New Jersey Wing of the Air Force Association for his "outstanding leadership in creating a consciousness of the need for a national policy for the aircraft industry to provide the continuing air power essential to national defense." **MICHAEL STROUKOFF** (left), president and chief engineer of Chase Aircraft and last year's trophy winner, presented the award to Hurley. Keynote speaker at the annual convention of the New Jersey AFA Wing was Gill Robb Wilson (right), aviation journalist and editor and a former trophy winner.

At a recent dinner in Hurley's honor on the occasion of his birthday, the board of directors of Curtiss-Wright presented him with a plaque for his "continuing contributions to the advancement of Curtiss-Wright and of the aircraft industry." Birthday present was a 17-foot sailboat.

Five SAE members have been elected officers of the Engineering Society of Detroit for the coming year. **EARL BARTHOLOMEW** of Ethyl Corp.'s Research Laboratory again serves as second vice-president. Treasurer will be **KENNETH R. HERMAN**, vice-president of Sperry Corp. Others serving on the board of directors will be **J. L. McCLOUD** of Ford, retiring president of ESD; **ALLEN C. STALEY**, Chrysler Corp. (retired); and **GRANT S. WILCOX** of Chrysler.

CAPT. JOE SHERMAN of the U. S. Air Force is now stationed at the research and development laboratories of the Corps of Engineers at Fort Belvoir, Va., as Air Force field engineering representative. He was previously at the equipment laboratory at Wright Air Development Center, Dayton, Ohio.

J. GEORGE PENN has retired from his post of assistant to the general plant manager of Michigan Bell Telephone Co. in Detroit. He will continue to live at 139 Cambridge Boulevard, Pleasant Ridge, Mich.

DAVID H. C. HOH is now research engineer for Kiekhaefer Aeromarine Motors, Inc., Fond du Lac, Wis. Hoh was previously junior design engineer for Cherry-Burrell Corp., Cedar Rapids, Iowa.

A. A. SCHMUDDE has been promoted to special technical representative for Caterpillar Tractor Co. Schmudde will give technical assistance in diesel application to distributors in New York, Pennsylvania, Connecticut, New Jersey and Toronto. He was previously a sales engineer for Caterpillar.

PROF. AMOS E. NEYHART, head of the Penn State Institute of Public Safety, has announced the 14th Annual Motor Fleet Supervisor Training Course to be held at Penn State from Sept. 22 to 26. The intensified course is aimed at fleet personnel who supervise commercial drivers. From Sept. 30 to Oct. 2, Penn State will conduct a Traffic Engineering Conference, with well-known representatives of the field leading discussion.

MURRAY FAHNESTOCK, editor of Ford Field Magazine, and his wife, Hazel, recently gave a sketch-talk titled "U-Auto-Know" over WDTV, Pittsburgh's only television station. Slanted towards the ladies, Murray's talk stressed the relation of car bodies to feminine fashions, from the flat-sided cars of the '20s through the streamlined beauties of the '30s to the present trend toward bustle-back cars. Mrs. Fahnestock, a former advertising artist, admits she doesn't always understand the gadgets she draws . . . once identified a valve as a piston before a group of experts.

RONALD A. HENDERSON, who was previously executive vice-president and manager of American Trailer and Engineering Co., Ltd., Honolulu, T. H., is now manager of the automotive division of Dillingham Brothers, Ltd., also in Honolulu.

WILLIAM C. HOWARD, JR., is now truck sales manager of Lawrence Motor Co., Richmond, Va. Howard was formerly with the National Production Authority in Washington, D. C.

MAHARAJ KRISHEN MEHTA has returned to India from Canada to set up a plant for R. P. Scherer India, Ltd. Mehta will be plant manager of the new establishment. Before joining R. P. Scherer in Windsor, Ont., a year ago, Mehta was with General Motors India, Ltd., in Bombay.

WILLIAM M. WALWORTH, vice-president of engineering of Reo Motors, Inc., has announced the establishment by Reo of a cooperative engineers training program with Michigan State College, starting with the fall semester. The plan will be open to juniors and seniors, who will spend three months attending college classes and three at the Reo plant. Working on a full-calendar year, students will complete their last two years of college in three years. The trainees will earn enough money at the Reo plant to defray basic college expenses during the three-year period, Walworth said.

DONALD W. FRISON is now assistant to the assistant sales director of the petroleum chemicals division of E. I. duPont de Nemours in Wilmington, Del. Frison was previously laboratory manager for the petroleum chemicals division in Tulsa, Okla.

FREDERICK C. RUSSELL is the author of "Fred Russell's Car Care," recently published by Fawcett Books. The book is aimed at the car owner. It tells him how to: detect car troubles, remedy them, break in a new car, operate a vehicle economically. It also discusses automatic transmissions, overdrives, and automatic tops. This 144-page book is available for 75¢ at newsstands.

MAJ. JOHN F. BEELER of the U. S. Air Force has been transferred to the HQ 3200th Proof Test Group at Elgin Air Force Base, Fla. He was previously stationed at HQ North East Air Command in St. Johns, Newfoundland.

RAYMOND J. CARTER has joined Precision Pump Co., Chicago, Ill. Carter was formerly design and development engineer for Gaylord Products, Inc., also in Chicago.

F. R. FLAHERTY is now sales representative for Grey-Rock Division of Raybestos-Manhattan, Inc., Manheim, Pa. He was formerly associated with Norwood Automotive Parts Corp., Norwood, Ohio.

KARL B. RAHAM is now operating the Memorial Park Service Station in St. Catherines, Ont. Raham was previously with Imperial Oil, Ltd., Sarnia, Ont.

CHARLES C. ADAMS has been promoted to project engineer in the engineering research department of Ford Motor Co. Adams was previously layout draftsman at Ford's engineering laboratory.

MYRL A. LINDEMAN is now research engineer at the automotive laboratory of Sun Oil Co. at Marcus Hook, Pa. Lindeman was previously at Sun's physical laboratory at Newtown Square, Pa., as mechanical engineer.

HARRY GUTTMAN is now assistant project engineer with Houde Engineering Division of Houdaille-Hershey Corp., Buffalo, N. Y. Guttman was previously with the Symington-Gould Corp., Depew, N. Y.

S. S. PIERCE is now chief of the methods and industrial engineering section of the Air Force Maintenance Division, Air Materiel Command, at Wright-Patterson Air Force Base, Dayton, Ohio. He was previously assigned to General MacArthur's staff at Supreme Command, Allied Powers, in Tokyo.

HARRY E. MILLER, JR., is now junior designer with the Industrial and Marine Engine Division of Reo Motors, Inc., Lansing, Mich. Miller was formerly foreman for GMC Detroit Transmission Division in Detroit.

WILLIAM S. MATTHEWS, JR., is now project engineer on bearing applications for textile machinery for GMC's New Departure Division, Bristol, Conn. He was previously general applications engineer for the division.

NORMAN L. BOOHER is now with Douglas Aircraft Co., El Segundo, Calif., as engineering draftsman. Booher was formerly junior engineer for Bendix Products Division of Bendix Aviation Corp. in South Bend, Ind.

Goodyear Names Lee Division Manager

WALTER J. LEE (left), assistant general manager of the rim division of Goodyear Tire and Rubber Co., has been promoted to general manager of the division. He succeeds **JOSEPH G. SWAIN** (right), who has been general manager since 1933. Swain will continue as consulting manager.

THOMAS P. DALLOW is now at Wright-Patterson Air Force Base, Dayton, Ohio, making flight tests on new Air Force equipment submitted by Wright Field Laboratories. He was previously project engineer with the flight test division at the Naval Air Test Center in Patuxent River, Md.

CHARLES A. CHAYNE was general chairman of the 13-day General Motors Engineering Conference held June 18-July 1 in Detroit. Nineteen professors and administrators from universities throughout the country participated. Among the speakers were **CHARLES E. WILSON, C. L. McCUEN,** and Chayne.

LUDWIG L. MOTULSKY has joined Southwest Research Institute, San Antonio, Texas, as research engineer in the engine research laboratory. He was previously product test engineer for the transmission engineering department of International Harvester Co., Fort Wayne, Ind.

RAYMOND G. O'CONNELL, who was formerly district manager in Chicago for the Torrington Co., Detroit, is now district engineer for the company in Detroit.

JACK E. SCOTT has rejoined Northrop Aircraft, Inc., as design engineer on special weapons. Scott has been executive engineer and project coordinator for Harper Engineering Co., Allentown, Pa. He has previously been with Northrop for a total of five years.

JAMES D. BONNEVILLE is now with with Minneapolis-Honeywell Regulator Co. as design draftsman on aeronautical flight controls. He was formerly a junior engineer with Fairbanks, Morse and Co., Beloit, Wis.

HAROLD R. BOYER of General Motors is chairman of the advisory committee for the Fifth Annual International Aviation Exposition to be held August 30-Sept. 1. The Exposition, sponsored annually by the Aero Club of Michigan, will take place at Detroit Wayne Major Airport. General chairman of the event and president of the Aero Club is **C. J. REESE,** president of Continental Motors Corp.

JEAN W. ARNOLD, who was formerly manager of manufacturing engineering for Ford Motor Co., is now general manager of Erie Engine and Mfg. Co., Erie, Pa.

JOHN W. TUCKER is now industrial engine sales manager for Cummins Service and Sales Co., Los Angeles, Calif. He was previously sales representative for Hall-Scott Motor Division of ACF-Brill Motors Co. in Los Angeles.

JAMES G. DARBY has joined the aeronautical division of Minneapolis-Honeywell Regulator Co. as test engineer. Darby was formerly with Fairbanks, Morse and Co., Beloit, Wis.

Strictly Business

WALTER F. ROCKWELL, president of the Timken-Detroit Axle Co., recently returned from several weeks abroad, where he studied business conditions in the trucking and automotive industries in England, France, Belgium, Holland, Luxembourg, and Switzerland. Rockwell is a member of the SAE Finance Committee.

OBITUARIES

ARNOLD LENZ

Arnold Lenz, General Motors vice-president and Pontiac Division general manager, and his wife lost their lives on July 13 when their car struck a passenger train at a grade crossing near Lapeer, Mich.

The General Motors executive was 64, and had been with various divisions of the corporation since 1916. He was SAE vice-president representing production engineering in 1934, and was currently a member of the Production Activity Committee.

Lenz was born in Hauingen, Germany, and at the age of 14 entered the office of Sarasin, Staehelin and Co., Haagen, as an apprentice. During his four years with the company he attended a technical extension school.

He came to the United States in 1906, and attended the New York State Normal School for two years. After working as molder, coremaker and melter, and later as foreman for several foundry companies, he joined American Range and Foundry Co., Cleveland, as assistant to the manager.

In 1916 Lenz took the post of foundry instructor for Buick Motor Co. in Flint. The same year he was promoted to general foundry foreman and assistant superintendent. After serving as assistant to the manager of Aluminum Casting Co., Detroit, for a few months in 1919, he returned to General Motors as superintendent of the Grey Iron Foundry of Saginaw Products Co. In 1922 he became plant manager and in 1925 assistant general manager of Saginaw Products.

When Chevrolet Motor Co. took over the Grey Iron Foundry from Saginaw Products in 1927, Lenz transferred to Chevrolet as foundry manager. He was named assistant manufacturing manager in 1932 and placed in charge of the Flint, Saginaw, and Bay City plants of Chevrolet; in 1941 his responsibilities were extended to cover Detroit, Toledo and Muncie.

Lenz was manufacturing manager of the Chevrolet-Cleveland Division for a year before being named executive assistant to the general manager of Pontiac Division in 1947. He became general manager of Pontiac on January 1, 1951, and was elected a vice-president of General Motors shortly afterward.

In recognition of Lenz' contributions to the foundry industry, the University of Aachen, Germany, conferred the honorary degree of Doctor of Engineering upon him in 1934. The following year he received the Whiting Gold Medal of the American Foundrymen's Association.

Lenz had been an officer of many civic and business organizations, and served as president and chairman of the Board of Regents of General Motors Institute from 1934 to 1944.

An avid sportsman, he particularly enjoyed hunting and fishing, and took a constructive interest in conservation.

Lenz lived with his family on a farm in Grand Blanc, Mich., north of Pontiac, and took pride in his stock of beef and dairy cattle.

Lenz and his wife, the former Amelia Kempter, leave three daughters.

CARL AXEL GUSTAFSON

Carl Axel Gustafson, assistant chief engineer of Caterpillar Tractor Co., died at his home in Peoria, Ill., on June 28. He was 61.

Gustafson had been with Caterpillar and the Russell Grader Mfg. Co., which was later absorbed by Caterpillar, for 40 years. He was the holder of more than 40 patents for road building and earthmoving equipment devices.

Born on a farm near Vermskog, Sweden, Gustafson constructed simple machinery for farm use as a boy. He was later apprenticed to a Swedish manufacturing company, and in 1910 came to the United States, settling near Minneapolis, Minn.

The following year Gustafson joined Russell Grader Mfg. Co. in Minneapolis, and advanced rapidly. During the accelerated production of World War I, he was chief engineer and factory manager.

When the Russell Co. was acquired by Caterpillar in 1928, Gustafson was relieved of his duties as factory manager to devote his time to engineering. The Caterpillar grader plant was moved to Peoria in 1928, and Gustafson went with it to take charge of road machinery engineering. He assumed responsibility for the development of Caterpillar earthmoving equipment in the late 1930's.

Photography and classical music were Gustafson's hobbies. He was a member of the Westminster Presbyterian Church in Peoria, and gave generous support to community welfare organizations.

Gustafson is survived by his wife, a son and three daughters, and four grandchildren; and by four sisters living in Sweden.

LOUIS THOMS

Louis Thoms, 57, died June 21. He was head of General Motors product studies 1 and 2 at the GM Technical Center in Detroit.

Thoms joined General Motors in 1935, and after several months with GM Overseas Division was transferred to product study group 1. He was named head of the group in 1936, and in 1947 was appointed head of both groups 1 and 2.

Thoms was born in Oak Park, Ill., and took his B.S. in mechanical engineering at the University of Michigan. During World War I he served as a civilian engineer at the Washington Navy Yard, working on early wind tunnel experiments in naval aeronautics.

He entered the automotive field in 1918, working for several truck companies before joining Graham Brothers Truck Co. at Evansville, Ind. By 1923 he was chief engineer of the company, and later held the same post with Graham-Paige Motors in Detroit.

A member of SAE for more than 30 years, Thoms served on SAE's War Engineering Board during World War II. He was also a member of the American Ordnance Association and the Detroit Athletic Club.

Thoms is survived by his wife and four sons.

HOWARD COOPER

Howard Cooper, manager of technical services for the lubricating sales division of Sinclair Refining Co. in New York City, died June 27 after a long illness. He was 61 years old.

Cooper was born in Chicago and graduated from Armour Institute of Technology with a BS in mechanical engineering in 1913. He entered the field of lubrication engineering during World War I, when he served as a first

lieutenant in the U. S. Army Air Service, working on lubrication problems of aircraft engines.

He joined Sinclair in 1922 in Chicago, and was transferred to the New York office in 1932. He was named chief engineer in 1937 and manager of technical services for the lubricating division in 1950.

Cooper had been a member of SAE for nearly 30 years, and was a member of several other technical societies. He was a past president of the National Lubricating Grease Institute.

He is survived by his wife.

WALLACE CHARLES DEVEREUX

Col. Wallace Charles Devereux, C.B.E., died June 21 at Ascot, England, at the age of 58. He was managing director of Almin, Ltd., which he founded in 1945, and director of a number of other companies for light metal research and production.

An outstanding figure in Britain's light metal industry, Col. Devereux entered the field after serving as superintendent of National Aircraft Factory No. 1 during the first World War. In 1927 he founded High Duty Alloys, Ltd., for research and development leading to the production of new alloys for the aircraft industry. In 1939, the Air Minister paid tribute to Devereux's contributions to the quality of R.A.F. aircraft.

During World War Col. Devereux served the Ministry of Aircraft Production as director of light alloy forgings from 1939 to '41, and as controller of American aircraft supplies from '41 to '42. In addition to other duties, he directed large-scale surveys into the problems of post-war industry during the latter years of the war.

In 1945, Col. Devereux founded the Associated Light Metal Industries Group—Almin, Ltd.—spanning the industry from raw material to finished product. He also founded Fulmer Research Institute to carry out research for individual companies.

Col. Devereux was an enthusiastic farmer as well as an industrialist. He founded the first commercial artificial insemination center in England, which was later taken over by the Ministry of Agriculture, and carried out agricultural experiments at his Buckinghamshire farm. He was president of the Bucks County Show for 3 years, and was a past Master of Fox Hounds of the Old Berkeley and South Oxfordshire Hunts.

He was a member of the Royal Aeronautical Society and vice-chairman of the Royal Aero Club, and had been an SAE member since 1935.

Col. Devereux is survived by his wife, two sons and four daughters.

SAE Members Are Saying . . .

"The jokes and jibes that sprang up a decade ago about synthetics have disappeared with the appearance of hundreds of products made wholly or in part of petrochemicals that are synthetic materials. Synthetics are replacing many natural materials that are difficult or impossible to obtain in sufficient quantities, and at the same time are proving that synthetic materials possess superior qualities. Petrochemicals have been one of the major factors in the beneficial revolution." . . . **Dr. W. E. Kuhn,** manager, technical and research division, The Texas Co., in an article in the Texaco Star, Petrochemical Number.

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"When the people of a community meet their own problems, in their own way, and solve them by their own efforts, they are helping everyone in a traditional American way. . . . We serve ourselves and our neighbors, and we buttress our freedom and opportunity, when we perform good works in our own towns." . . . **L. L. Colbert,** president, Chrysler Corp., in talking to the Cleveland Automobile Dealers' Association, June 5.

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"It may be that we are at the threshold of an era in which we shall enjoy far wider ability to adapt the physical character of metals to the needs of the mechanical arts; and, in particular, to develop new metals with characteristics which will better enable them to meet new engineering requirements heretofore considered impossible." . . . **Alfred P. Sloan,** chairman of the board of General Motors Corp., in dedication exercises of the new metals processing laboratory, at Massachusetts Institute of Technology, June 3.

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"The prime requisite for safe, dependable hydraulic braking is the use of a quality fluid that equals or surpasses the specifications set up by the Society of Automotive Engineers. Manufacturers whose fluid meets these rigid specifications will readily display the SAE specification on their containers. Look for it." . . . **W. R. Freeman,** chief engineer, automotive division, Wagner Electric Corp., in an article "Bad Brake Fluids . . . Unrecognized Killers!" in the Wagner Circle, June, 1952.

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"When we boil the fundamentals down, we find five motivating forces: Fear, Hunger, Sex, Instinct, and Reason. . . . To insure victory against Communism, we must remove the causes of fear in society; abolish hunger; strengthen the family institution; quiet instinctive reactions of disturbed people; and use the power of reason to set a sound course for the world." . . . **R. M. Keyes,** vice-president of General Motors and general manager of GMC Truck & Coach Division, in an address to the Pacific Regional Conference of vocational agriculture education state supervisors and teachers.

Students Enter Industry

RICHARD T. KOWALSKI (New York University '51) is a mechanical engineer at Portsmouth Naval Shipyard, Portsmouth, N. H.

MAX R. PETERSON (Parks College '51) is now a flight test instrumentation engineer for Boeing Airplane Co. in Wichita, Kans.

MATTHEW CHIONCHIO (Case Institute of Technology '51) has joined the Griscom-Russell Co., Massillon, Ohio, as research and test engineer.

CLIFFORD R. EPPLEY (University of Pittsburgh '51) is with Consolidated Vultee Aircraft Corp., San Diego, Calif., as junior engineer.

BRUCE THOMAS (Virginia Polytechnic Institute '51) is a material review inspector with Piasecki Helicopter Corp., Morton, Pa.

WILLIAM H. MUELLER (Bradley University '51) is now with Davenport Besler Co., Davenport, Iowa, as mechanical engineer.

DAVID S. WEINMAN (New York University '51) is specifications engineer for Leeds and Northrup Co., Philadelphia, Pa.

CRAY L. FOLEY (Oklahoma A & M College '51) is in Burbank, Calif., as research technician for Lockheed Aircraft Corp.

RAY W. COTTER (University of Buffalo '51) is with the Cornell Aeronautical Laboratory, Inc., in Buffalo, N. Y., as project engineer.

JEROME YUTKOWITZ (College of the City of New York '51) is employed at the New York Naval Shipyard, Brooklyn, N. Y.

EUGENE N. BORSON (University of California '50) is now with Helipot Corp. in South Pasadena, Calif.

DONALD A. NOETH (Academy of Aeronautics '51) is an aircraft engine inspector with Glenn L. Martin Co., Baltimore, Md.

ALVIN H. MURPHY (Catholic University of America '51) is an engineering draftsman with Lockheed Aircraft Corp., Burbank, Calif.

WILLIAM F. CHAPLE (University of Oklahoma '51) is with Goodyear Tire & Rubber Co., Akron, Ohio, as a staff trainee.

WILLIAM L. POUND (University of Michigan '51) is with Proctor & Gamble Mfg. Co., Chicago, as an industrial engineer.

ROBERT M. BADGER (Tri-State College) is a senior draftsman with Goodyear Aircraft Corp., Akron, Ohio.

GLENN D. REINDERS (Bradley University '51) is a laboratory technician with Chrysler Corp., Highland Park, Mich.

ARTHUR A. ROGERS (General Motors Institute) is a tool engineer with Rochester Products Division of General Motors Corp., Rochester, N. Y.

RICHARD H. DONLON (University of Wisconsin '51) is an engineering aide with N.A.C.A. Lewis Flight Propulsion Laboratory, Cleveland Airport, Cleveland.

JOHN C. WOODEN (Tri-State College '51) is a draftsman with Sylvania Electric Products Inc., Seneca Falls, N. Y.

RALPH J. PECORA, JR. (Pennsylvania State College '51) is with Texas Co., Beacon, N. Y., as a mechanical engineer.

KENDALL D. LOILER (General Motors Institute '51) is now with Chevrolet-Saginaw Transmission, Saginaw, Mich.

A. JOHN KARVONEN (Michigan College of Mining and Technology '51) is now with Ford Motor Co., Ypsilanti, Mich.

HAROLD R. KAUFMAN (Northwestern University '51) is a research assistant with National Advisory Committee of Aeronautics, Cleveland Airport, Cleveland.

PAUL T. JOHNSON (Case Institute of Technology '51) is a junior engineer with Euclid Road Machinery Co., Cleveland.

GORDON W. JACOBSON (Michigan College of Mining and Technology '51) is now with Detroit Diesel Division of General Motors Corp., Detroit.

THOMAS S. WILSON (Rensselaer Polytechnic Institute '51) is a mechanical engineer with Behr Manning Corp., Watervliet, N. Y.

JAMES E. BRITT (Washington State College '51) is an electronic scientist at the U.S. Navy Electronics Laboratory, San Diego, Calif.

ROLLIN E. SHANKLE (Northrop Aeronautical Institute '51) is a design engineer with Consolidated Vultee Aircraft Corp., San Diego, Calif.

LESLIE I. C. MORSE (Tri-State College '51) is a tool engineer with Parker Appliance Co., Cleveland.

EDWARD G. BROWN (Michigan State College '51) is a junior engineer with Wright Aeronautical Corp., Wood-Ridge, N. J.

JAMES R. PHELAN (University of Detroit '51) is a project engineer with Detroit Bevel Gear Co., Hamtramck, Mich.

FLOYD S. NEFF (California State Polytechnic College '51) is with George B. Erskine & Associates, Menlo Park, Calif., as a junior mechanical engineer.

JAMES W. MOORE (Parks College '51) is an officer in the U.S. Air Force at Keesler Air Force Base, Miss.

HOWARD O. MIELKE (Carnegie Institute of Technology '51) is a draftsman detailer with Euclid Road Machinery Co., Cleveland.

HARRY L. McMULLIN, JR. (Southern Methodist University '51) is now with Allis-Chalmers Mfg. Co., Milwaukee.

ROSS W. McCORMICK (Purdue University '51) is a time study engineer with Fairfield Mfg. Co., Lafayette, Ind.

WARREN P. McCLURE (University of Pittsburgh '51) is an engineer apprentice with Mesta Machine Co., West Homestead, Pa.

GORDON W. WOODS (Drexel Institute of Technology '51) is a weight engineer with Kellett Aircraft Corp., Camden, N. J.

CORNELIUS FIOCCO (Case Institute of Technology '51) is a product engineer with Lamson and Sessions Co., Cleveland.

HERBERT W. SALTZMAN (New York University '51) is with Arma Corp., Brooklyn, as a junior test engineer.

OTIS A. SCHMIDT (Northwestern University '51) is a sales manager with Broadview Iron Shop, Inc., La Grange, Ill.

ROBERT C. SCHOPPER (Carnegie Institute of Technology '51) is a student engineer with Duquesne Light Co., Pittsburgh.

THOMAS F. RUNYAN (Lawrence Institute of Technology '51) is with Allied Research Designers, Inc., Clawson, Mich., as a machine designer.

GORDON C. RUCKS (University of Wisconsin '51) is a laboratory engineer with Kiekhaefer Aeromarine Motors, Inc., Fond du Lac, Wis.

ROBERT G. REEVES (College of the City of New York '51) is a junior engineer with John Reiner & Co., Long Island City, N. Y.

SHELBY O. MARTIN (University of Southern California '51) is an officer in the U.S. Air Force.

Continued on Page 126

TECHNICAL COMMITTEE *Progress*

Chrysler's R. N. Janeway is chairman of the SAE Riding Comfort Research Committee, which has released its "Ride and Vibration Terminology" for publication in the 1953 SAE Handbook

New Ride and Vibration Terms Resolve Two More Woes of Engineers

CHALK up another assist to the SAE Riding Comfort Research Committee. Its recently prepared "Ride and Vibration Terminology" provides still one more way to promote riding comfort qualities of passenger cars. Just as a previous committee report shows how to interpret vibration measurements in terms of passenger discomfort, so this new terminology should put an end to two more woes of suspension engineers.

First and foremost, it's going to help them talk the same language . . . and that's important. No longer should such terms as amplitude and double amplitude, or shock absorbers and snubbers, be confused.

What's more, the simple, short definitions outlined in this new "primer" should help engineers in possibly their most difficult task—explaining ride and vibration terms to executives.

So far the terminology contains six sections, ranging from types of mechanical vibration and vibrating systems . . . to characteristics of suspension systems and suspension geometry. But the committee feels it needs at least one more—a section on tire terminology—and it's hard at work on it. When completed, the committee plans to submit this tire jargon to the Tire & Rim Association for its comments and suggestions.

The first six sections of this ride and vibration terminology package have already been approved by the SAE Technical Board and will be published in the 1953 SAE Handbook. They're available now, however, as SP 6A, Ride and Vibration Terminology. Price: 50¢ to members, $1 to nonmembers.

R. N. Janeway, of Chrysler, heads up the Riding Comfort Research Committee. Credit for developing these six sections of the terminology goes to Terminology Subcommittee members W. S. Berry, Nash; R. W. Brown, Firestone; Maurice Olley, Vauxhall; V. D. Polhemus, General Motors Technical Center; Robert Schilling, Research Laboratories, GMC; and C. A. Tea, Ford. Watson Ford, of U. S. Rubber, heads up the subcommittee preparing the tire terminology section.

Other members of the Riding Comfort Research Committee include: A. C. Bodeau, Ford; L. M. Ball, Chrysler; H. E. Fox, General Motors' Truck & Coach; Tore Franzen, Chrysler; D. E. Goldman, Naval Medical Research; W. E. Lay, Michigan; Howard Magrath, Aircraft Laboratories, Dayton Air Force Base; J. M. Nickelson, Michigan; B. E. O'Connor, Houdaille-Hersey Corp.; E. F. Rossman, Delco, GMC; H. P. Roth, Protection, Inc.; J. L. Searle, Detroit Steel Products; and Harcourt Sontag, Bureau of Aeronautics, Navy Dept.

1952 SAE Technical Board

G. A. Delaney, Chairman

P. C. Ackerman	R. P. Lewis	F. N. Piasecki
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Several Changes Made In SAE Carbon Steels

ONE steel, SAE 1009, has been added to the list of SAE standard steels. Three others—1034, 1114, and 1116—have been deleted.

Application of the designations SAE 1111, SAE 1112, and SAE 1113 to steels of appropriate chemistry made by the basic open hearth or basic electric steel making processes as well as by the Bessemer process has also been authorized.

These changes have been approved by Division VII-Carbon Steels and its parent committee, the SAE Iron and Steel Technical Committee, and by the SAE Technical Board. The changes have the approval of the American Iron and Steel Institute also. The steel tables of the 1953 SAE Handbook will be revised accordingly.

Ladle analysis for the new SAE 1009 is:

element	%, maximum
carbon	0.15
manganese	0.60
phosphorus	0.040
sulfur	0.050

These limits for SAE 1009 encompass those for SAE 1006, SAE 1008, and SAE 1010. There are many applications where it doesn't matter which of these three low-carbon steels is used. In these cases, SAE 1009 can be speci-

fied on drawings instead of a choice of all three steels.

The plain carbon steel 1034 and the free-cutting steels 1114 and 1116 were deleted because surveys showed very limited use.

SAE 1111, SAE 1112, and SAE 1113 have formerly been listed as Bessemer steels. But producers say that the time is not far off when virtually no steel will be produced by this process. Therefore, Division VII recommended that although the steels may still be known as "Bessemer" steels, the SAE table of free-cutting steels be revised to include a footnote that "These steels may be produced by the basic open hearth or basic electric steel making practices." (This table is part of the standard on "Chemical Compositions of SAE Carbon Steels" and appears on page 44 in the 1952 SAE Handbook.)

48 AMS Approved By Technical Board

FIVE new and forty-three revised SAE Aeronautical Material Specifications were approved recently by the SAE Technical Board. They are:

- AMS 2808A—Identification, Forgings
- AMS 3130A—Paint Vehicle, Glyceryl Phthalate
- AMS 3132A—Varnish, Synthetic Resin, Corrosion Preventive
- AMS 3150B—Fluid — Hydraulic, Interim-Nonflammable Type
- AMS 3160A—Solvent, Petroleum
- AMS 3165A—Solvent, Petroleum, Aromatic
- AMS 3170A—Thinner, Alcohol—Ester
- AMS 3180B—Toluene Thinner, Commercial
- AMS 3201D—Synthetic Rubber, Dry Heat Resistant (35-45)
- AMS 3202D—Synthetic Rubber, Dry Heat Resistant (55-65)
- AMS 3204C—Synthetic Rubber, Low Temperature Resistant (25-35)
- AMS 3205C—Synthetic Rubber, Low Temperature Resistant (45-55)
- AMS 3207C—Synthetic Rubber, Weather Resistant—Chloroprene Type (25-35)
- AMS 3208C—Synthetic Rubber, Weather Resistant—Chloroprene Type (45-55)
- AMS 3209 C—Synthetic Rubber, Weather Resistant—Chloroprene Type (65-75)
- AMS 3220A—Synthetic Rubber (55-65)
- AMS 3232F—Asbestos and Synthetic Rubber Sheet, Hot Oil Resistant
- AMS 3412A—Flux, Aluminum Brazing
- AMS 3414A—Flux, Aluminum Welding
- AMS 3605B—Plastic Sheet, Post-Forming, Cotton Fabric Reinforced Phenol-Formaldehyde
- AMS 3806A—Cloth, Airplane, Cotton, Mercerized, 80 lb Breaking Strength
- AMS 4010—Aluminum Alloy Foil, 1.2 Mn(3S-H18);
- AMS 4135G—Aluminum Alloy Forgings, 4.5Cu - 0.9Si - 0.8Mn - 0.5Mg(14S-T6)
- AMS 4139E—Aluminum Alloy Forgings, 5.6Zn-2.5Mg-1.6Cu-0.25Cr(75S-T6)
- AMS 4140D—Aluminum Alloy Forgings, 4Cu-2Ni-0.7Mg(18S-T61)
- AMS 4150B—Aluminum Alloy Extrusions, 1Mg-0.6Si-0.25Cu-0.25Cr(61S-T6);
- AMS 4152E—Aluminum Alloy Extrusions, 4.3Cu-1.5Mg-0.6Mn(24S-T4);
- AMS 4153A—Aluminum Alloy Extrusions, 4.5Cu-0.9Si-0.8Mn-0.5Mg(14S T6);
- AMS 4154D—Aluminum Alloy Extrusions, 5.6Zn-2.5Mg-1.6Cu-0.25Cr(75S-T6);
- AMS 4156A—Aluminum Alloy Extrusions, 0.65Mg-0.4Si(63S-T6)
- AMS 4360C—Magnesium Alloy Forgings, AZ80A, Precipitation Heat Treated
- AMS 4770B—Brazing Alloy, Silver, 50Ag-18Cd-16.5Zn-15.5Cu
- AMS 4772A—Brazing Alloy, Silver, 54Ag-40Cu-5Zn-1Ni
- AMS 4880—Aluminum Bronze Cast-

Technishorts . . .

HYDRODYNAMIC DRIVE SPECS—A code for indicating on colored or black-and-white drawings the pressures prevailing in the various passages of hydrodynamic drive units is under consideration by a subcommittee of the SAE Hydrodynamic Drive Committee. O. K. Kelley of General Motors is chairman of the subcommittee. Additions to the SAE specs on hydrodynamic drive terminology and symbols and changes in the laboratory test code have also been proposed to the subcommittee.

NEW SPONSORS—H. W. Browall of Inland Steel has been appointed Technical Board sponsor for the SAE Iron and Steel Technical Committee, and R. P. Lewis has been appointed sponsor for the SAE Parts and Fittings Committee.

BORON STEEL BOOMS—Boron steel production was about 58,000 ingot tons per month before the steel strike began, E. J. Hergenroether of the National Production Authority reported to the June 2 meeting of the executive committee of the SAE Iron & Steel Technical Committee. That represents about 8% of all alloy steel production, he said.

RADIATOR CORE PICS—The SAE Standard on Radiator Nomenclature will soon take on a new look. The radiator core nomenclature is going to be augmented with a descriptive perspective sketch of each type of core. This should reduce the possibility of confusing these five basic types, the SAE Truck & Bus Technical Committee agreed at its June 3 meeting.

STANDARD TRUCK WHEELS would be a boon to fleet operators . . . but is standardization of truck wheels feasible? That's what a newly constituted SAE Truck & Bus Technical Committee group has been asked to find out.

To test the feasibility of such a program, this subcommittee will investigate possible interchangeability of 20-, 22-, and 24-in. disc wheels and other smaller diameter wheels interchangeable on the same mountings.

ings, Centrifugal, 81.5Cu-10.3Al-5Ni-2.8Fe, Heat Treated

- AMS 5382B—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-25.5Cr-10.5Ni-7.5W;
- AMS 5504B—Steel Sheet and Strip, Corrosion Resistant, 12.5Cr-(SAE 51410);
- AMS 5511A—Steel Sheet and Strip, Corrosion and Heat Resistant, 18Cr-8Ni(304L);
- AMS 5576—Steel Tubing, Welded, Corrosion and Heat Resistant, 18Cr-10Ni-Ti(SAE 30321);
- AMS 5610E—Steel, Corrosion and Moderate Heat Resistant, 13Cr Low Carbon (SAE 51416F), Free Machining
- AMS 5620B—Steel, Corrosion and Moderate Heat Resistant 13Cr(0.30-0.40C) (SAE 51420F)-Free Machining
- AMS 5636A—Steel, Corrosion Resistant, 18Cr-8Ni-(SAE 30302) Cold Drawn—100,000 psi
- AMS 5637A—Steel, Corrosion Resistant, 18Cr-8Ni-(SAE 30302) Cold Drawn—125,000 psi
- AMS 5646C—Steel, Corrosion and Heat Resistant, 18Cr-11Ni-(Cb+Ta) (SAE 30347)
- AMS 5688C—Steel Wire, Corrosion Resistant, 18Cr-8Ni-(SAE 30302)—Spring Temper
- AMS 5720A—Steel, Corrosion and Heat Resistant, 20Cr-9Ni-1.4Mo 1.4W-(Cb+Ta)-Ti
- AMS 5721B—Steel, Corrosion and Heat Resistant, 20Cr-9Ni-1.4Mo 1.4W-(Cb+Ta)
- AMS 5733—Steel, Corrosion and Heat Resistant, 13.5Cr-26Ni-3Mo-1.8Ti
- AMS 5784—STEEL WIRE, CORROSION AND HEAT RESISTANT, 29Cr-9Ni

Which Dimensions For Flywheel Housing?

FOR a future SAE No. ½ size flywheel housing, would you prefer a 24⅜-in. diameter bolt circle and a 25½-in. flange or a 24-in. diameter bolt circle and a 25⅛-in. flange?

That's the question being asked by the Clutch Housings, Clutch Mountings, and Flywheel Subcommittee of the SAE Engine Committee and the Engine Standardization Subcommittee of the SAE Construction and Industrial Machinery Technical Committee.

Engineers who wish to register a preference or comment on the dimensions should write promptly to the staff secretary, David L. Staiger at SAE headquarters, 29 West 39 St., New York 18, N. Y.

25 Years Ago

Facts and Opinions from SAE Journal of August, 1927

To few men comes the signal honor of accomplishing so superb a feat as that achieved by Charles L. Lawrance—designing the engine that carried Lindbergh, Chamberlin, Byrd, Maitland, and Smith in their successful transoceanic flights. This Wright Aeronautical president is largely responsible for bringing the air-cooled radial engine to its present state of consummate excellence.

■

Automobile manufacturers blame shimmy on tires; tire manufacturers in turn shift the responsibility back to automobile manufacturers. So long as this condition exists, we cannot look for much improvement. Let's all step in and shoulder our portion of the blame, take our medicine, and correct the fault instead of shifting it to someone else.—John F. Duby, of John F. Duby Co., in discussion of K. L. Herrmann's Annual Meeting paper.

■

Most of those who object to the four-speed transmission have had little or no actual experience with it. To appreciate it fully, one must give it a very thorough try-out under a great variety of driving conditions.—S. O. White, of Warner Gear Co., in discussion of his Semi-Annual Meeting paper.

■

An instrument or process that would indicate or register noise in a practical manner would be a great asset in modern-day mass production. Securing inspectors whose sense of hearing is keen enough to enable them to "standardize" to a point where uniformity of product results is very difficult.—R. R. Todd, Oakland Motor Car Co.

■

Aluminum alloys possess two characteristics which make them most desirable for use as piston material—light weight and high thermal conductivity. Their only drawback—coefficients of expansion more than twice that of cast iron—can be overcome by properly designing pistons.—G. D. Welty, of Aluminum Co. of America, in Buffalo Section paper.

■

There seems to be a tendency at present to feature alloy-steel castings. Such castings are desirable and necessary in some services but in many cases, they contain numerous shrinkage cavities, gas pockets, sand inclusions, and cracks. It's a waste of good material to use steel alloys in any and all applications.—H. H. Lester, of Watertown Arsenal, in Detroit Section paper.

■

Six months ago many manufacturers were experimenting with metal brake linings and wouldn't consider testing the newer asbestos-fiber linings. Now these same manufacturers are again back to testing fabric linings.—A. M. Yocom, Multibestos Co., in discussion of H. D. Church's Semi-Annual Meeting paper.

SAE Section Meetings

Military Needs Force Jet Development

• Central Illinois Section
G. W. Eger, Field Editor

May 26—At the last regular meeting of the Central Illinois Section for the year, the Section honored those members who have belonged to the SAE 25 years or more. Members in attendance so honored were:

J. W. Bridwell, Caterpillar Tractor Co.
H. A. Fletcher, Caterpillar Tractor Co.
S. W. Gray, Marvel-Schebler Products Division
C. M. Hewitt, Bradley University
J. T. Liggett, Allis-Chalmers Mfg. Co.
H. W. Smith, Caterpillar Tractor Co.

Members of 25 years or more who were not at the meeting are:

A. C. Boock, Allis-Chalmers Mfg. Co.
E. F. Norelius, Allis-Chalmers Mfg. Co.
J. A. Polson, University of Illinois
J. W. Hobbs, John W. Hobbs Corp.

Arch Colwell, vice-president of Thompson Products and former president of the SAE, told the Section members that there is a revolution at present in the aircraft industry. Colwell stated that although reciprocating piston engines will still be used for a long time, military requirements are demanding the advancement of the jet engines for aircraft. The Air Force wants higher speed and more power to go through the sonic barrier. They want to climb faster, go to higher altitudes and be able to send their planes greater distances. Cost must be secondary; these items are not compatible with economy.

Today's bombers are faster than the fighter aircraft at the end of World War II and the only way that fighters can be effective is to be faster than the bombers. Speeds in excess of 600 mph have to be built into today's fighters, and such speeds pose numerous problems. Not only does the power plant for such aircraft present a problem, but the controls and the mechanisms necessary to allow a person to ride that plane also present their problems.

Everything in the plane of today has been improved but the human being who is piloting that plane. Present planes give the person only 20 seconds to drop his bombs and consequently electronic controls have taken over in this and other instances. These controls necessitate the miles of electrical wiring in modern planes. Colwell stated that the electrical system of a Mustang plane of World War II was like a door bell system compared to the electrical system of a Sabre plane. A bomber today costs about 3½ million dollars, and over one-half of that cost goes into electrical equipment.

Colwell stated that the turbine prop engine would find a place between the piston engine and the jet. The jet engine is the leveler; great amounts of power are available in the jet, but the piston engine will still find lots of application for many years and the turbine prop engine will be used for larger cargo and even greater ranges.

Colwell predicted that in six years, jet engines will develop at least 16,000 lb of thrust as compared to present values of 3,000; that engines will weigh ½ lb per pound of thrust and will handle 300 lb of air per second. He stated that future bombers would weigh 400,000 lb and carry payload of 100,000 lb at double piston engine bomber speeds, over a range of 3500 miles.

Colwell was introduced by H. H. Howard, director of sales for Caterpillar Tractor Co. J. W. Bridwell, assistant chief engineer of Caterpillar, was after-dinner speaker.

Reevaluates Atom Bomb Dangers

• Washington Section
Lewis C. Kibbee, Field Editor

May 20—The final meeting of the 1951-52 sessions of the Washington Section was conducted this evening with a Ladies Night program. The speaker for the evening was **Lt. Col. Gerald M. McDonnel**, Office of Surgeon General, U. S. Army, whose subject was "The Atom Bomb and You." Colonel McDonnel gave an up-to-the-minute critique of practical suggestions

At the season's final meeting, Central Illinois Section honored 25-year members of SAE; later heard A. T. Colwell speak on present and future aircraft needs. Left to right: Section Chairman J. W. Vollentine; J. W. Bridwell, who was after-dinner speaker; A. T. Colwell; and H. H. Howard, technical chairman of the meeting

to be followed in case of an atomic bomb explosion.

He stated that the stories concerning the bomb are becoming less and less fantastic and people are now realizing the original claims were grossly exaggerated. In the speaker's opinion the general public does not have a proper understanding of the potential hazards and how to combat them; as a result, widespread and false rumors have frightened people beyond the true dangers. Radiation from the bomb has been grossly overplayed and it is now understood that with proper precautions personnel can live close to a bomb explosion and enter the radiation area without undue hazard.

Prior to the meeting the officers and chairman for the succeeding year were introduced.

The session was opened in advance of the meeting with a short hospitality hour sponsored by several firms and individuals represented in the Section membership. Corsages were presented to the ladies and a gala and interesting evening was had by all.

Chrysler Institute Wins Model Engine Trial

• Detroit Section
George J. Gaudaen

April 21—Present and the future student engineers provided the entertainment and interest at the annual meeting sponsored by the Student Activity of Detroit Section at the Rackham Memorial Building. Current student engineers from six local colleges showed their skill in a model aircraft engine horsepower contest which was captured by the Chrysler Institute entry. The technical session was devoted to a talk on the future for engineering students entitled "Trends in Engineering Education" by **Dr. Frederick L. Hovde**, president of Purdue University.

The engine contest was a demonstration of student ingenuity in modifying a basic model engine to develop the most horsepower. When the contest started, the only thing common to the six entries were their 10-in. propellers. To assure that differences would not be nullified by a judge's error, an electronic timer was used to record the engine's revolutions per minute, the basis for determining the relative horsepower.

When the smoke and castor oil fumes had cleared, it was found the 10,489 rpm recorded by the Chrysler Institute engine had edged out the entry from the Detroit Institute of Technology which developed 10,135 rpm. University of Michigan, University of Detroit, Lawrence Institute of

SAE Student News

Cal-Aero Technical Institute

Robert B. Beltz, electro-mechanical engineer in charge of test and research for Vard Engineering, Inc., was speaker at the May 7 meeting of the SAE Student Branch at Cal-Aero. Vard's Chief Engineer Parmiter was also a guest.

Beltz' brief talk described electro-mechanical devices on modern aircraft, including control actuators, anti-icing systems, and so forth.

—William Wong

Wayne University

Student Branch members at Wayne closed the spring term with a trip to Ethyl Research Corp. in conjunction with the ASME Student Branch on May 29, talks and movies, and plans for the coming term.

The engineers took time out from technical activities to enjoy a movie on "Highlights of the Detroit Lions 1951 Season" after the March 24 business meeting. At the May 19 meeting, T. A. Boyd of General Motors Research Laboratories Division spoke on "Engineering and Research."

The SAE Student Branch contributed a skit to the spring "Engineers' Blowout," and William Birge and F. Wichman volunteered to serve as leaders for the engineering orientation classes in fall.

—Chester J. Selden

College of the City of New York

Chrysler's new V-8 engine was described in detail at the May 15 meeting of the SAE Student Branch in a joint talk by Albert Glantz and Vincent Farley, both of Chrysler Motor Parts Corp. Using charts of performance curves and sectional views of the engine, the speakers explained the factors that result in the engine's high efficiency.

Before the talk, Glantz and Farley were taken on a tour of CCNY's mechanical engineering laboratories, and spent some time in the new metal processing laboratory. Luncheon in the school's faculty restaurant followed. The visit and talk was arranged through the help of Maurice Rice, regional service manager for Chrysler Motor Parts Corp.

—Morton Nashman

University of Oklahoma

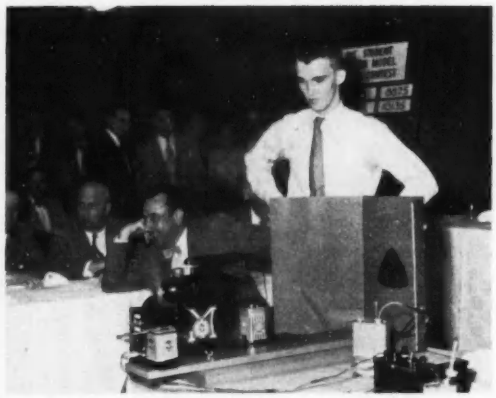
At the final meeting of the year on May 14, the SAE Student Branch at the University of Oklahoma re-elected T. J. McDuffie chairman for the coming year. H. V. Abrahms was chosen for vice-chairman, and J. W. McDermott will be secretary-treasurer.

Student Branch activities for the school year 1951-52 included a sports car show, a float for Homecoming Day constructed jointly by the Branch and ASME student members, a lecture and exhibit of LPG conversions for automobiles and aircraft, and a talk on "Opportunities in the Steel Testing Industry." Authorities on highway safety, construction and planning, law enforcement, and fuel projection participated in a panel discussion on safety. The Student Branch also took an active part in the University's annual Engineer's Open House.

Professor E. M. Sims of the School of Mechanical Engineering will be faculty adviser for the coming year, succeeding Professor Charles J. Mauck.

—J. W. McDermott

Detroit Section hears Purdue President, holds student contest



President F. L. Hovde of Purdue University spoke on the outlook for engineering students at the April 21 meeting of Detroit Section, while P. H. Pretz (left) of Ford and B. W. Bogan of Chrysler Corp. listened from speaker's platform. . . . Before the talk, SAE enrolled students showed what they could do in stepping up the horsepower of model aircraft engines. At right, Clare Parker of the University of Michigan puts Michigan's streamlined model through its run. The entry took third place, developing 9946 rpm

At left, the six model engines that competed in the annual Detroit Section student contest are lined up, showing little in common but their ten-inch propellers. Chrysler Institute's prize-winning entry is second from left. . . . The winners: Bruce Hanna of Chrysler Institute of Technology holds the winning engine, while Chrysler student Charles Chapman points to the rpm score that won them first place. B. W. Bogan (right), Detroit Section vice-chairman for students, made the award

Technology, and Wayne University entries trailed the leaders in that order.

Dr. Hovde stated that polices of the engineering schools during the next decade would be based on the fact that the number of engineering graduates would fall far short of the number needed to fulfill the requirements of industry. Estimates of the number of engineers needed annually, he noted, vary from 32,000 to 80,000. Starting with a peak of 30,000 graduates this year, the engineering schools will be turning out an average of less than 20,000 engineers per year for the next eight years.

The basic trend among engineering schools in view of this, he noted, is one of encouraging a general as contrasted to a technical education. The schools emphasize that learning is a continuing process and that, supplied with a broad foundation, the student can more readily acquire the specialized job knowledge he needs after leaving school. In this manner the quality of the instruction can be maintained and courses need not be lengthened.

As an aid to the self-education trend, Dr. Hovde pointed out that more schools are developing extension programs. These programs enable the graduate engineer to work toward advanced degrees with a minimum of time loss from his industry position.

The biggest ray of hope in the dark picture, he felt, is the industriousness of the younger generation. This and improved school facilities will assist in meeting the problem at hand.

Crossdrive Transmission for Tanks Replaces Torqmatic and Differential

Based on paper by

J. E. STORER

General Motors Corp.

THE Crossdrive transmission has made possible a power package for tanks which is 27 in. shorter than the previously used combination of Torqmatic transmission and controlled differential. Comparison between these two units is shown in Fig. 1. The engines develop comparable power, but with the Crossdrive package close to a 50% weight reduction was effected.

Outstanding features are the hydraulic drive or torque converter, planetary gearing, and force controlled steering and service brakes. These are arranged compactly in an aluminum housing. The drive comprises a GM polyphase four element hydraulic converter with lockup. This gives automatic adjustment of torque output to the torque required to move the vehicle. Gearing contains two planetary sets for range selection and two for delivering drive to output flanges.

The converter pump is in constant engagement with the engine through a gear train. The converter itself has a 3.9:1 stall torque ratio and delivers the ratio required by road load, or goes into lockup at the established vehicle speed, transmitting its power through low, high, or reverse to the output planetary gears, then to the output universal joint flanges. Steering power is taken between converter output and planet gear sets. In forward and reverse motion all power flows direct to the output ring gears regardless of the transmission gear being used. The output sun gears are stationary because of the balanced torque reactions on the steer train differential gearing. Steer power can be tapped from the converter drive by actuating the steer clutches.

The Crossdrive permits quick diagnosing for trouble and speedy teardown for repairs. A few repairs and all adjustments can be made without removing the package from the vehicle. Pressure gages can be spotted at pressure points on the transmission so that troubles can be located quickly and analyzed. (Paper, "Military Torque Converter Transmissions for Track-Laying Vehicles," was presented at SAE National Passenger Car, Body, & Materials Meeting, Detroit, March 6, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

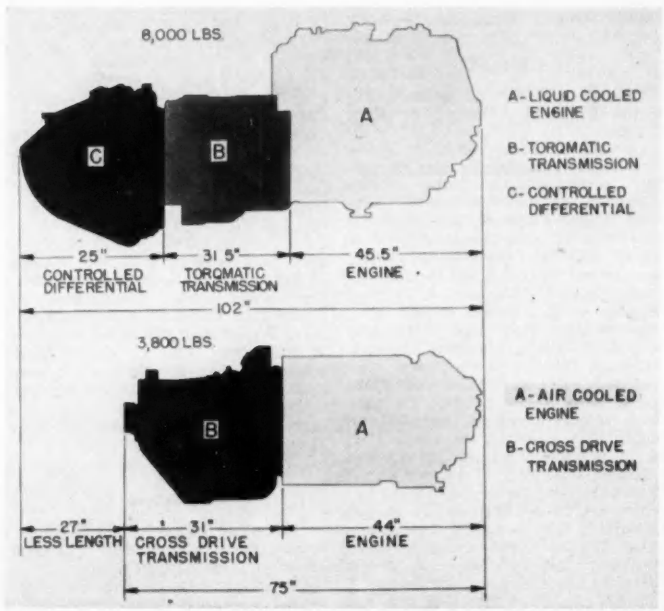


Fig. 1—Profile comparison between Crossdrive and Torqmatic transmissions, showing compactness of the newer Crossdrive type

Aircraft Selection Is No Easy Matter

Based on paper by

G. R. McGREGOR

Trans-Canada Air Lines

AIRCRAFT ordered today cost so much, take so long to deliver, and must be kept in service so long, that the airline operator is faced with a real dilemma when it comes to deciding which type of aircraft to order.

A four-engine craft may cost anywhere from 1½ to 2¼ million dollars. No matter how successful an operator is, or how carefully he watches costs, he cannot usually hope to write off his investment in less than five years—and a seven-year depreciation rate has become more usual.

The operator can be fairly sure, therefore, that whatever aircraft he orders today must still be in service seven years hence. And he is confronted, not with the relatively unimportant variations on a single design which were available a few years ago, but with the radically different conventional, jet, and turboprop engines.

If he orders piston engines, he takes a chance on their passenger appeal dropping considerably by 1956 or 1957.

If he chooses turboprop engines, probably a good compromise in fuel consumption between piston and jet engines, he knows little about his probable maintenance costs.

If he orders full jet engines, he knows most of his operations must be conducted at 35,000 ft or over, and that he is going to run into traffic problems at crowded airports.

That the solution is far from clear-cut is shown by the variety of paths chosen by major operators. Orders have been placed for full jet engines, for turboprops, for orthodox piston engines, and for compound engines. In choosing the latter, Trans-Canada Air Lines took into account the scarcity of cost information on full jet and turboprop engines, and also its desire to remain more or less uncommitted on new types of power until more information was available. Super Constellations seemed to be the best compromise. They deliver better horsepower than straight piston en-

Continued on Page 108

SAE Section Officers

Baltimore

Chairman: **Ward L. Bennett,** Superintendent of automotive equipment, Baltimore Transfer Co.

Vice-chairman: **Robert M. Foster,** M.E., U. S. Naval Engineering Experiment Station; Annapolis, Maryland; vice-chairman aeronautics: **Robbert W. Scarborough,** Engineer "A", Charge, Power Plants-Heat & Vent Aid Anticing, Hayes Aircraft Corp.; treasurer: **Carl K. Kummerlowe,** Automotive Engineer, Department of the Army, Ordnance Department, Automotive Division, Development & Proof Services, Aberdeen Proving Ground, Maryland; secretary: **William H. Wilson, Jr.,** Sales, Aluminum Co. of America.

British Columbia

Chairman: **Edward C. Howell,** transportation manager, Evans, Coleman & Evans, Ltd.

Vice-chairman: **Alan B. Reid,** truck sales manager, Wolfe Chevrolet Oldsmobile, Ltd.; vice-chairman Fuels and Lubricants: **Arthur R. Brown,** president, Brown Fraser & Co., Ltd.; vice-chairman Transportation and Maintenance: **K. M. Wilson,** president, general manager, Wilson Equipment Co., Ltd.; treasurer: **W. H. Weish,** service manager, Lawson Oates Motors, Ltd.; secretary: **John B. Tompkins,** editor, Westrade Publications.

Buffalo

Chairman: **Clifford J. Lane,** president, Lane Engineering Co.

Vice-chairman: **Benjamin Fuente,** project engineer, Houde Engineering Division, Houdaille-Hershey Corp.; secretary-treasurer: **Elliot W. Chapman,** industrial salesman, Esso Standard Oil Co.

Canadian

Chairman: **A. Wallace Denny,** vice-president, charge of production, Goodyear Tire & Rubber Co. of Canada, Ltd.

Vice-chairman: **A. A. Scarlett,** vice-president (Engineering.), International Harvester Co. of Canada, Ltd.; vice-chairman Hamilton: **Douglas M. Park,** vice-president, Wallace Barnes Co., Ltd.; vice-chairman Kitchener: **W. E. Ireland,** vice-president, B. F. Goodrich Rubber Co. of Canada, Ltd.; vice-chairman Niagara Peninsula: **J. E. Gammage,** Sales Manager, Hayes Steel Products, Ltd.; vice chairman Oshawa: **Harold A. Washington,** Plant Manager., Ontario Steel Products Co., Ltd.; vice-chairman Sarnia: **John W. Leach,** Field Engineer, Imperial Oil, Ltd.; vice-chairman Windsor: **John A. Dykes,** Parts & Service Engineer, Chrysler Corp. of Canada, Ltd.; treasurer: **Harold C. Brindle,** vice-president, Charge Sales, Auto Electric Service Co., Ltd.; secretary: **Alex L. Gray,** vice-president, general manager, Gray Forgings & Stampings, Ltd.

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for 1952-53

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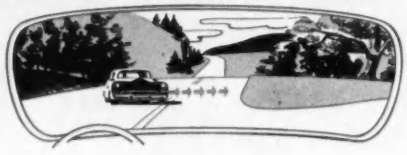

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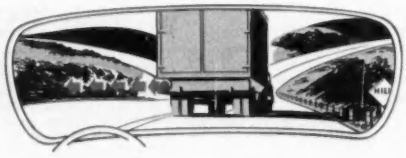

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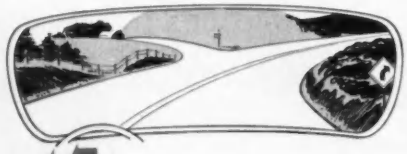

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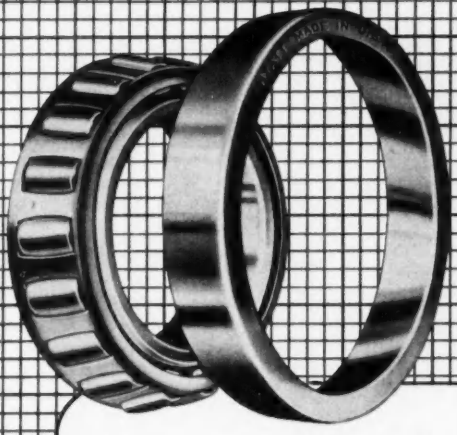

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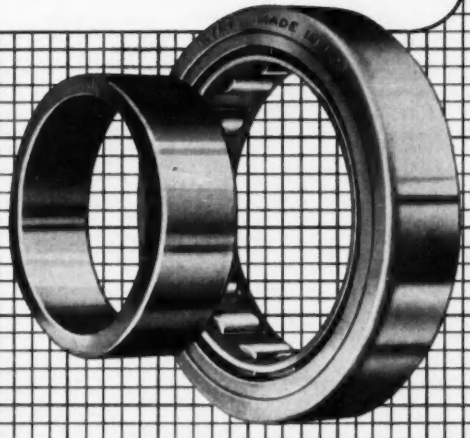

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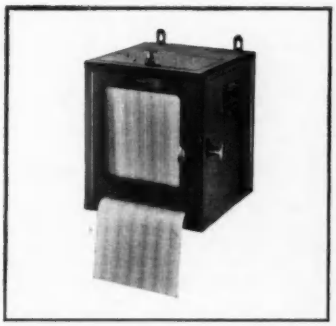
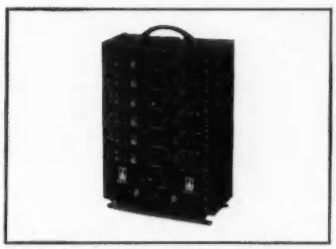
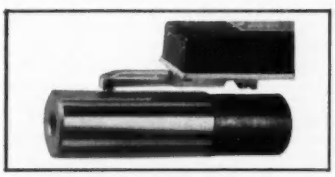


RECORDS SIX VARIABLES SIMULTANEOUSLY. The Brush six-channel Magnetic Oscillograph is designed for simultaneous recording of six electrical and/or mechanical phenomena, with a chart record instantaneously available. This instrument facilitates multiple strain measurement, vibration analysis, wind tunnel work, circuit analysis, etc. Built-in gear changer provides instantaneous shift from high to low speed; wide choice of chart speeds available.

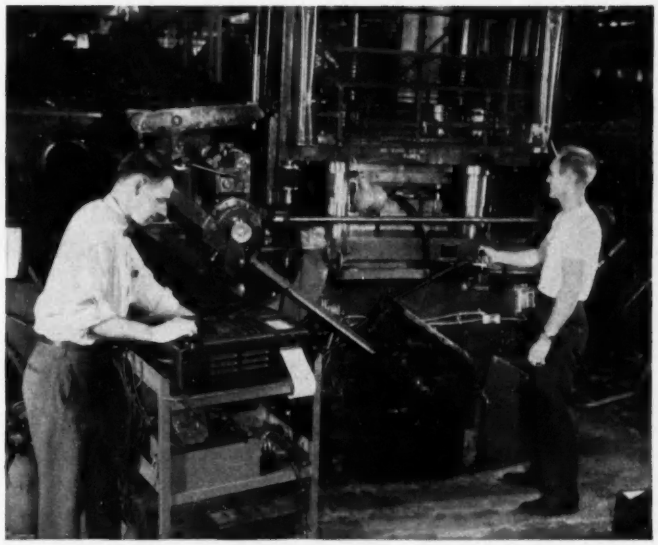


RECORDS SIX VARIABLES CONSECUTIVELY. If simultaneous strain measurements are not necessary, consecutive measurements can be made with substantial saving in equipment cost. The Universal Bridge Switch, when coupled with a Brush Universal Analyzer and two-channel Magnetic Oscillograph, permits consecutive recording of strain measurements from six different locations on the structure or specimen being tested. One of the two channels of the oscillograph records strain, the other channel indicates the location of the particular strain measurement.



CHARTS SURFACE PROFILE. As this Brush Pickup probes the surface on the cylindrical piece, a chart is drawn by a Brush Surface Analyzer . . . giving positive, numerical recording of the surface profile. Surface irregularities of less than 1 micro-inch can be measured accurately. Brush Surface Analyzers eliminate guesswork in specifying and checking finishes on various surfaces: metal, plastic, glass, paper, etc. In addition to chart recording, *average finish* is indicated on a large illuminated scale.

For catalog describing these Brush instruments, write The Brush Development Company, Dept. EE-34, 3405 Perkins Avenue, Cleveland 14, Ohio.



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Technical Digests

Continued from Page 99

gines, can make the Montreal-London flight non-stop, and will give the company a few years' grace in which to accumulate and evaluate cost and performance data on new types of powerplant.

The next five years probably will see both full jet and turboprop civil aircraft in regular, successful service. Full jets will be used for medium and long range routes, turboprops for routes under 600 or 700 miles. The larger companies probably won't buy aircraft seating less than 35 passengers, and specifically-designed cargo planes probably will be used quite generally. Traffic will undoubtedly continue to increase, and one of the greatest civil aviation problems will still be air traffic control. Its solution will be neither simple nor rapid nor cheap. (Paper, "The Evolution of Civil Aviation," was presented at SAE Montreal Section, Dec. 10, 1951. It is available in full from SAE Special Publications Department. Price: 25¢ each to members, 50¢ to nonmembers).

Heavy Equipment Needs Cleaning Before Repair

Based on paper by

HAROLD L. McCORMACK

Caterpillar Tractor Co.

THE first step in the proper repair of diesel engines and earthmoving equipment is to clean it thoroughly. Cleaning makes disassembly quicker, makes possible the inspection and evaluation of the parts removed, and encourages good workmanship in reassembling. No single method of cleaning will do the job any more than one wrench will suffice for the rebuilding of an engine.

The steam cleaner is the most widely used machine, but since it is subjected to much abuse and requires considerable upkeep, it is wise to choose one which gives the greatest accessibility to parts most likely to need replacement or servicing. Another device which should be in every shop is the high-pressure water washer. The right combination with this device appears to be a pressure of 400 psi with a volume of 12 to 14 gal per min. This machine enables a track type tractor to be washed in 4 to 6 hr as

Basic Bearing Refinements

CUT TRUCK MAINTENANCE!

Fundamentally, America's truck owners buy ton-miles! And they want them at the lowest possible cost! That's why wise truck manufacturers who realize the importance of precision-built bearings to dependable truck performance standardize on Bower *Spher-O-Honed* bearings. Basic bearing refinements—mirror-smooth finish, generous oil groove, millionth-inch tolerances—are only a few of the many important Bower features. They are specifically designed to reduce maintenance to a practical minimum—add mile upon mile to the life of the bearings. Whatever your product, if it uses bearings you'll be wise to equip it with longer-lasting Bower *Spher-O-Honed* bearings.

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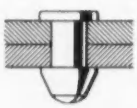
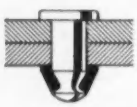


when the outside of the HI-SHEAR collar is neatly formed and trimmed . . .



the inspector knows that the collar solidly fills the grooved end of the pin.

Only HI-SHEAR trims the collar as it drives . . . the positive check for tool wear, correct pin length and complete driving.

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contrasted with 8 to 10 hr using steam.

For cleaning oil soaked and dusty parts a good method is to let them stand in a soluble oil type solvent for not less than 20 min, then remove the soil with high pressure water. A 30 gal tank containing solvent diluted about 1 to 7 is about right. For cleaning similar parts at the point of disassembly a handy device consists of a 5 gal container on which is mounted an air actuated agitating device.

Still another type of cleaner comprises a 5 gal container holding solvent into which such items as small carburetor and magneto parts can be lowered by basket. The purpose of this device is primarily for specialized cleaning at the point where repetitive repairs are made. Parts covered with oil, but practically free from dust and dirt, can be cleaned readily by the vapor degreasing method. This treatment assures the removal of all the deposits from diesel engine cylinder blocks so that contaminants causing wear will be disposed of properly. (Paper, "The First Step—A Discussion of Cleaning Methods Used in Heavy Equipment Repair Shops," was presented at SAE Central Illinois Section, Peoria, Ill., Dec. 17, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Tracing Microphonics To Faulty Vacuum Tubes

Based on paper by

T. H. McNARY

Boeing Airplane Co.

TESTS of 32 vacuum tubes, representing eight types, revealed that most tubes are mechanically weak, while dissection after failure determined that poor workmanship often makes them weaker. This indicates that many perturbations found in equipment circuits may have been caused by mechanical resonance in the tubes themselves rather than emanating from couplings, "crosstalk", or other electronic means.

Two 6J6 tubes were found to be defective when taken from stock; several tubes failed while under vibration. Examination of some of the failures revealed many weaknesses. One 6C4 tube failed early in test due, it developed, to a weld failure between Pin No. 5 and the corner of the plate structure. The grid assembly of one 6J6 was very loosely mounted while another had a small piece of foreign matter lodged between the grid and the cathode. The cathode connector lead broke on one 6AL5 tube.

All the tubes showed definite resonant conditions. The type 6J6 was most consistent in that resonance was found at approximately 3500 cps in each sample. The 6AL5 type showed the least noise of any tube tested.

Although results of the tests were qualitative, enough quantitative indications were obtained to show a sufficient magnitude in the problem to warrant further investigation, and to suggest that corrective steps in design, manufacture, and inspection of tubes should result in a product of greatly improved quality and reliability. (Paper, "Some Effects of Vibration Within Electron Tubes", was presented at SAE Annual Meeting, Detroit, Jan. 17, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

How the British Develop Air Transport

Based on paper by

R. C. MORGAN

British European Airways

IN the United Kingdom, the position of the two National Airways Corporations relative to industry and to the government supply departments is somewhat different from that of United States operators for two reasons:

1. The two Corporations account for the bulk of airline traffic.
2. The government has played a substantial part in the initial development of new civil aircraft types.

This relationship has enabled the Corporations to contribute to new development in a way which is perhaps novel to U. S. operators where in the latter case a new type results perhaps from the demands of numerous individual operators and the market being weighted by the manufacturer. The British Government has financed the development of new craft in the form of prototype contracts with manufacturers. Part of these funds has been allocated to proving flying to try out the planes under simulated service conditions before passengers are carried, while development contracts have been placed to cover other equipment such as engines and accessory items.

The cost of the production aircraft purchased by the airways is the commercial market price plus an amount per plane to enable the Government to recoup the cost of prototype construction and development.

Control of development finance is vested in the Ministry of Supply, and throughout the design and construction of these aircraft a very effective

How a

"talk in time"

reduced the cost of an engine!

A large midwestern manufacturer of farm machinery was designing an engine. Things were pretty well settled and production schedules were set up. Right about this time I called on the Company and had a chat with the President. When he showed me the blueprints, I immediately saw how a casting, with which we had considerable experience, could effect a substantial economy. After a few minutes figuring I said, "We can make a casting that can save you real money." Although dubious, the President called in his engineers. We talked—analyzed—sketched. I suggested a test casting be made immediately. It was—it proved successful. Today every one of that Company's engines has this casting—and every engine costs less!

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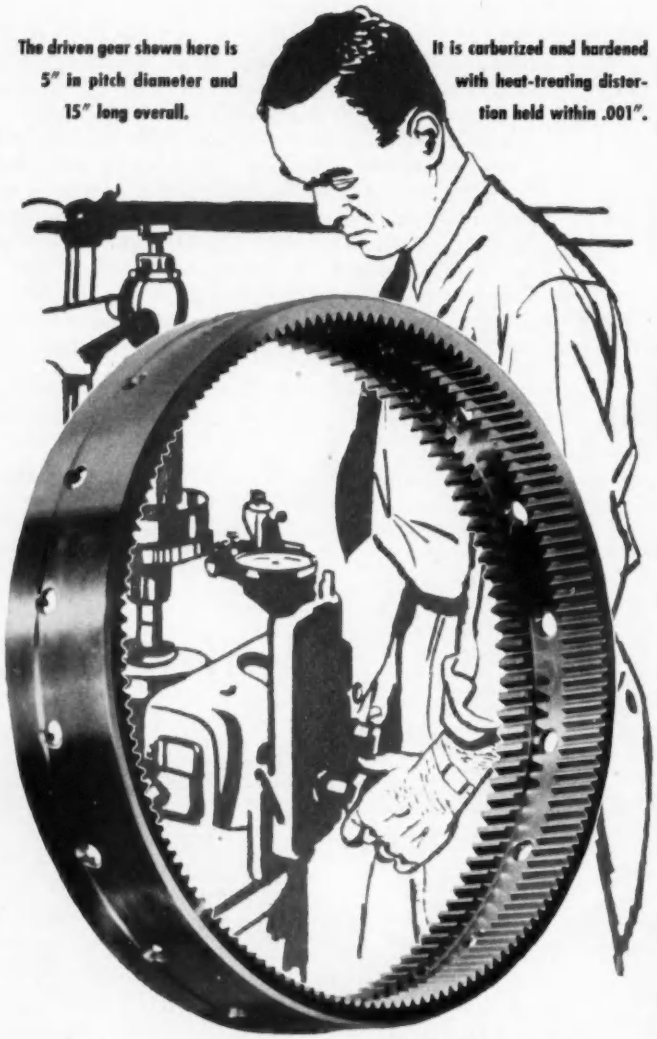
The driven gear shown here is 5" in pitch diameter and 15" long overall.
It is carburized and hardened with heat-treating distortion held within .001".

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working liaison has been maintained between manufacturers, the Corporation (airline), and the Civil Aircraft Directorate of the Ministry. (Paper, "Introduction of New Transport Aircraft," was presented at SAE National Aeronautic Meeting, New York, April 22, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Improvements Wanted In Earthmoving Engines

Based on paper by

H. LESLE RITTENHOUSE

The Euclid Road Machinery Co.

STANDARDIZATION of engine mountings to permit interchange of engines in the same vehicle would be very beneficial to earthmoving equipment users. It would also help to have a standard for the location of water connections on engines of similar size, and some standardization of fan sizes. There are times when it is highly desirable for the user to interchange accessories from one engine to another, such accessories being air compressors, engine starters, generators, filters, air cleaners, mufflers and hydraulic steering pumps.

It would be a marked improvement to so design engines that the hottest section of the exhaust is not adjacent to a point requiring frequent adjustment, or near the oil dip-stick. Also, there should be available improved mounting and additional drive shafts for hydraulic steering pumps. This is as important to the user as proper air compressor or generator drive outlets.

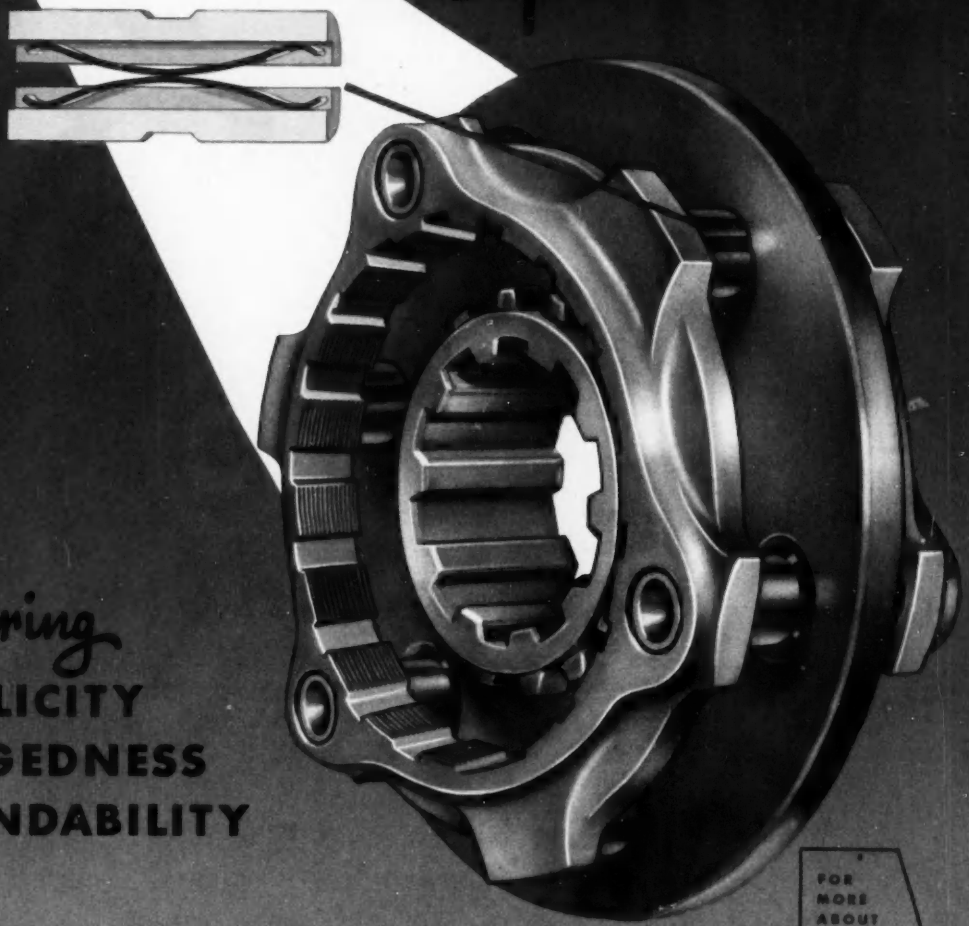
More research is needed on cold weather starting and operation problems. It is not unusual to see engines running idle for 48 hr because of inadequate provision for protection from cold. The maintenance of oil filters and air cleaners under extremely severe conditions consumes a valuable part of the possible productive life of a vehicle, hence a program to develop accessories which will give longer engine life with less servicing is in order. The goal to set for the life of a heavy-duty diesel engine might properly be to exceed 10,000 hr between overhauls.

Torque converters have grown steadily in popularity, but it would seem that as yet no heavy-duty engine has been designed to work exclusively ahead of a torque converter. It appears likely that if an engine were designed with this end use in mind, characteristics could be built into it which are not now there.

The exhaust bark of heavy-duty en-

CLARK THE

Split-Pin Synchronizer



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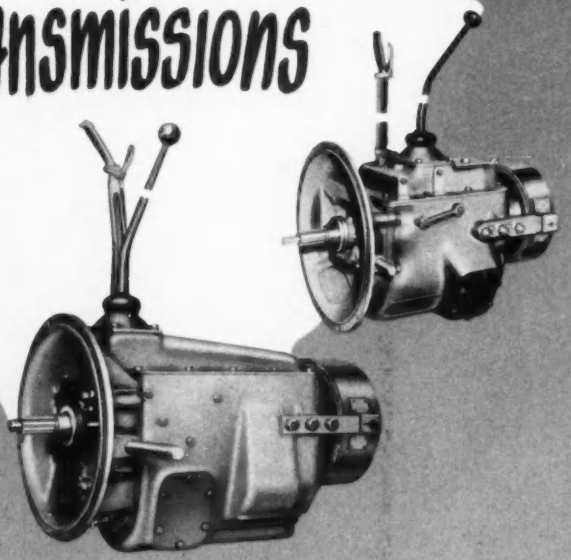
CLARK Transmissions



CLARK transmissions are now available featuring THE "SPLIT-PIN" SYNCHRONIZER. In keeping with its traditional enthusiasm for engineering development, Clark not only builds a full range of conventional models, but specializes in designing and producing transmissions for unusual requirements for trucks, buses, farm tractors, industrial trucks and road building machinery.

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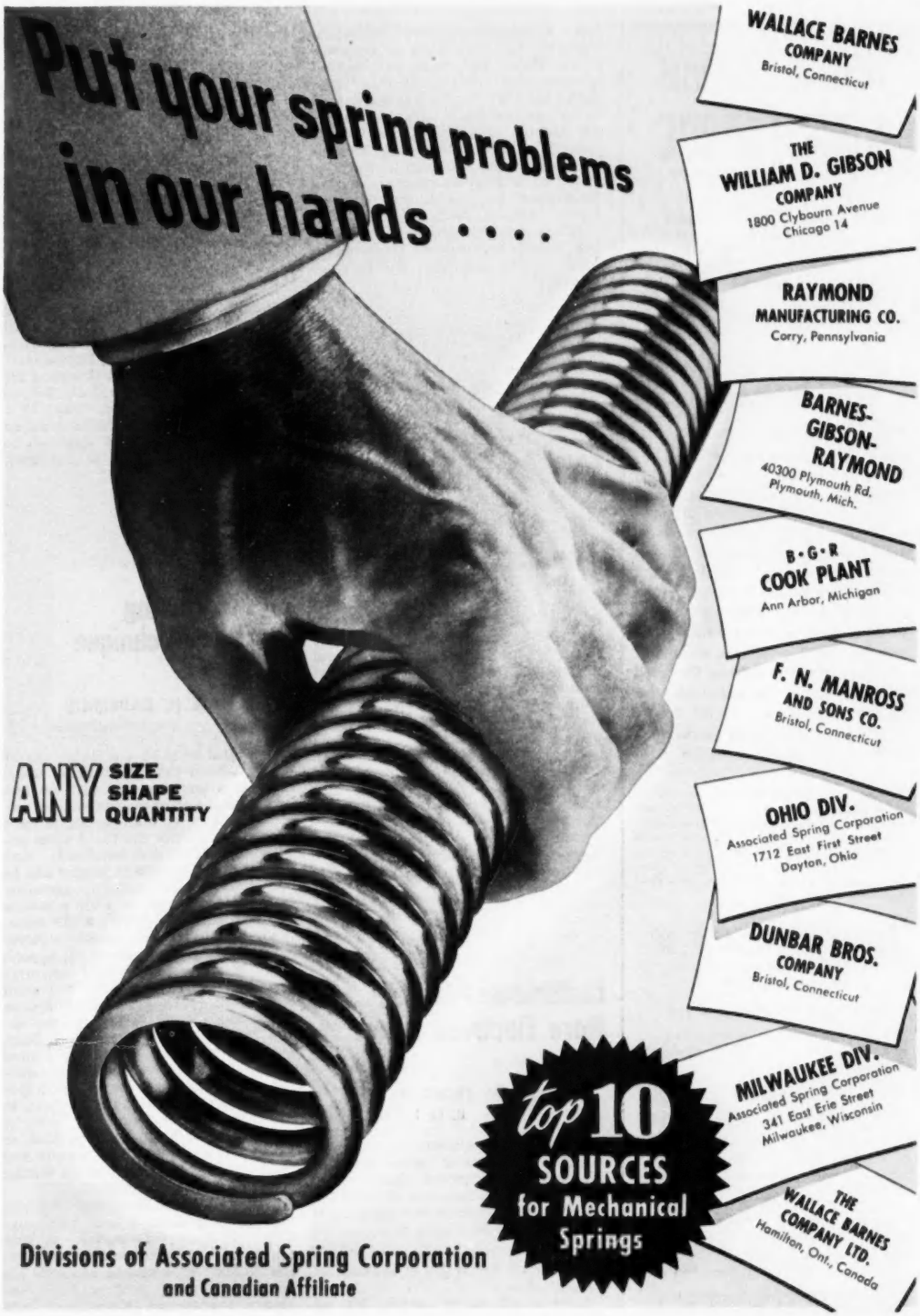
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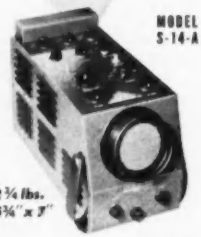
BY WATERMAN



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gines is another attention demanding characteristic. The noise is very close to the driver, and, since earthmoving is often done at night by many machines together, the bark is a nuisance to the neighborhood. This is a problem far too important to be treated casually. (Paper, "Selecting Engines for Earthmoving Equipment," was presented at SAE Earthmoving Industry Conference, Central Illinois Section, Peoria, April 10, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

What It Takes To Make a Rail Diesel

Based on paper by

R. H. WELLMAN
and
L. O. PARKER
General Motors Corp.

IN THIS paper the authors trace the history and development of General Motors' 567 Series locomotive diesel engine. They show how the engine itself dictated design changes and discuss the whys and wherefores of these changes in detail, not omitting frank statements about the failures involved in bringing this series to its present maturity. (Paper, "History and Development of the 567 Series General Motors Locomotive Engine," was presented at SAE Western Michigan Section, Feb. 13, 1952).

Earthmovers to Use More Electrical Power

Based on paper by

C. W. RICHARDS
R. G. LeTourneau, Inc.

SUCCESS with electric controls for performing many operations on earthmoving equipment presages the use of a full diesel-electric drive in the near future. Some of the advantages such a drive would have, are:

1. The even flow of power which has led to torque converters in mechanical power trains.
2. Packaged wheel power for all wheel drive, all wheel steer.
3. Elimination of mechanical drives which limit and often determine chassis and main case design.
4. Make easier the cutting in and out of power to any set of drive wheels at the operator's discretion.

Electric drive units are in the development stage and in some phases even beyond it. Machines for specialized use are now being manufactured on a limited scale. Both a-c and d-c power are being tried. For this use, a-c has a characteristic of speed control inferior to d-c, but the former is less susceptible to dust and water. Ultimately both systems may be used depending somewhat on the intended use of the machine. (Paper, "Electrical Operation of Earthmoving Equipment," was presented at SAE Earthmoving Industry Conference, Central Illinois Section, Peoria, April 10, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members; 50¢ to nonmembers).

Missile Testing Has Own Technique

Based on paper by

JESSE H. ZABRISKIE
Bell Aircraft Corp.

A MISSILE must have a higher degree of reliability than an airplane. Each flight is a one-way trip with no test pilot to make observations and adjustments. Cause of malfunction is hard to determine since the flight ends under extremely adverse conditions. And to assume that cause of failure can be determined easily from the operating facts of 30 components when a missile contains 500, just doesn't make sense.

The only approach to this problem is to carry the test program far beyond what would be considered adequate for planes and thoroughly test each component, subassembly and system individually and as a part of the entire missile before conducting flight test. Each system must be adjusted and aligned after assembly in the missile since it is the interaction of systems that causes most of the delay in test programs and probably most of the flight failures. It is possible to spend from three to five months and from 4000 to 6000 man-hours testing a missile in simulated flight.

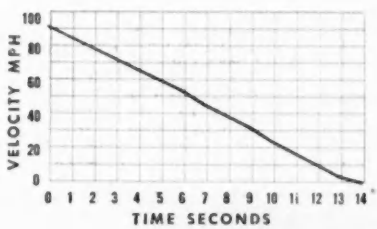
Overall reliability which depends upon the reliability of each part, governs the final performance. A 99% reliability level is not enough for missile design. If a missile contains 100 components, each with a 99% reliability, the overall reliability is only

How to absorb 25 million FT-LBS of energy in 1000 feet!

This deceleration chart shows what happens when a pilot brings his 20 ton ship in for a landing. During this stop, terrific heats and pressures are created. Yet planes must stop safely... and quick!

American Brakeblok attacked this problem during World War II. Working closely with aviation brake manufacturers we developed the formulas to do the job. We helped solve some very difficult manufacturing problems, created mass-production methods and equipment.

Today we are a major supplier of aviation brake lining. Our research laboratories, manufacturing facilities and years of experience are ready to serve—either for military or civilian needs.



American Brakeblok

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AMERICAN Brake Shoe COMPANY

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is proving effective even where other lubricants have failed

Moly-sulfide, a solid-film lubricant, is proving so useful in difficult friction applications that new uses are found daily. 154 cases of how serious problems were solved are described in our new booklet. Your own problems may be like those described. Write for your copy of this booklet.

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MOLY

SA-8 MS-8

36.5%. With 300 components the reliability drops to 6%. And the average missile has 500 components! Stated another way: if an overall reliability of 80% is assumed to be satisfactory, and a missile has 50 critical components, only one failure out of 225 components is permissable. With 300 components, only one failure out of 1350 is allowable. This means test programs should eliminate any single item which is not practically 100% dependable, which is contradictory to the notion that components can be designed for a short life.

Experience has shown that it is uneconomical to attempt to conduct the major portion of a test program at a missile test base. As much as possible should be done at or near the center of manufacture to shorten the program and reduce its cost. Experience also shows the development of test equipment to be a major part of the entire weapon development problem. (Paper, "Some General Aspects of Missile Testing," was presented at SAE Annual Meeting, Detroit, Jan. 17, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Makes Strain Gage Serve Many Purposes

Based on paper by

GEORGE A. REA

Heil Co.

THE electrical strain gage has been put to good use in several departments of the company. In the bottle washer department, it has been used to measure loads in various parts of the mechanism linkage. A special weighing link was devised to permit accurate weighing of some large pasteurizers and bottle washers which could not be weighed on platform scales. The oil burner division has used a dynamic analyzer together with a special diaphragm setup to measure and record combustion pulsation in a search for a quieter flame. The dump body and hoist department runs a complete static test on each experimental or pilot model and on each unit before it is placed in service. It also does field testing to check dynamic stresses in hoist structures as a truck traverses rough ground or dumps on uneven ground surfaces.

Pump research has been carried on with the aid of an especially built hydraulic "cell," to obtain oscillograph traces of gear pump pressure output. Fluctuations on top of the static pressure line were found to be due to gear tooth meshing and unmeshing, as might be expected. A possible explanation for relief valve chatter is apparent if one considers the possibilities of getting a resonant frequency between the pressure pulsations of the pump and the natural frequency of the relief valve spring. (Paper, "Strain Gages in Construction Machinery Design," was presented at SAE Milwaukee Section, March 7, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Mechanical Units Win In Truck Refrigeration

Based on paper by

HAROLD D. JOHNSON

U. S. Dept. of Agriculture

THE vast amount of frozen citrus concentrate being shipped from Florida by truck prompted a test to determine the relative merit of dry ice versus mechanical units for truck refrigeration. Out of these tests, which are continuing with various types of trailers, it was found that the mechanical unit did the better job.

The methods used to conduct these tests, with recommendations and suggestions applicable to the shipment of other types of frozen foods as well as the concentrate, are presented in detail in this paper. (Paper, "Refrigeration in the Transportation of Frozen Citrus Concentrate by Motor Truck," was presented at SAE Annual Meeting, Detroit, Jan. 14, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

User is Contributor To Earthmover Design

Based on paper by

HAROLD W. RICHARDSON

Editor, Construction Methods & Equipment

IT is not unusual for customers to place orders for earthmoving equipment never before built, unseen, untested, untried and unpriced and this demonstration of faith exemplifies the user's contribution to the development of earthmoving equipment. By and large development comes from cooperation between customer and machine

Bearing performance with Rolled Bushing Economy when you use our Bimetal Bushings

1 BEARING MATERIALS
Bronze, babbitt or copper-lead lining.

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Rolled from bimetal continuous strip.

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builder, and that is the way it should be.

Direct contribution by users is hard to trace. Some machines have been built in their entirety by users, but building from scratch to satisfactory performance is rare. Usually the contribution is in the form of partial development which the maker takes over to complete. Significant changes in existing machines have been made by users and advances in accessories and attachments have arrived that way. But it is the customers perennial dissatisfaction that contributes the most.

Designers should be aware of demands, needs and wishes of customers. They should get out and see machines in action. They should study changes made by users, learn what's wanted in equipment. They would find every user wanting more power, lower unit cost of performance, greater ruggedness and dependability, and less maintenance trouble. Contractors are becoming more maintenance minded. At the same time, the quality and skill of mechanics is deteriorating. Hence for proper maintenance and service all parts, however complicated, must be readily accessible. Ignore this demand and the customer will go elsewhere.

A tired operator is a poor producer, hence ease of control and smooth operation are essential. Designers should investigate closely the possibilities of improvement in electrical, hydraulic and pneumatic controls, and in individual electric and hydraulic drives. (Paper, "User's Contributions to Development of Earthmoving Equipment and Methods," was presented at SAE Earthmoving Industry Conference, Central Illinois Section, Peoria, April 9, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

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Automatic Shifting Means Quality Shifting

Based on paper by

CHARLES W. MERVINE

Chrysler Corp.

GEAR shifting by even the most skilled driver is subject to variations in quality, while the automatic transmission, sensitive to engine speed and torque, can foresee any change in conditions for a given shift and make all shifts uniformly well. If the transmission has planetary gear sets, making it unnecessary to interrupt engine torque for gear engagement, the shifts can be completed quickly and smoothly with very little change in the car's acceleration rate.

While four-speed transmissions give better performance than the conventional three-speed type, Americans seem not to favor them as the Europeans do, because of the effort of shifting. With an automatic transmission 99% of the effort is reduced and with this goes the superior performance possibilities of a four-speed transmission with fluid coupling or a two- or three-speed transmission with torque converter which assures a salable product. (Paper, "Why Automatic Transmissions?," was presented at SAE Detroit Section, Jan. 28, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Continued on Page 122

FRAM is FIRST in the Filter Industry *here's why*

Better Research, Development and Engineering Facilities

Within the finest research and development laboratories in the automotive filter field, alert Fram scientists and technicians constantly develop and perfect Fram products. After exhaustive performance tests in the laboratory, new Fram products and new developments of existing products are given intensive workouts on the Fram test fleet and in the famous Fram Dust Tunnel at Dexter, Michigan.

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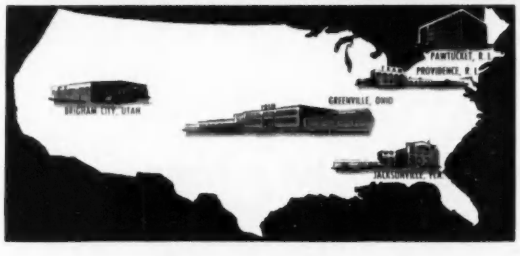
Complete engine protection from the outside and from within the engine itself is vitally important to continued top performance. Fram Oil, Air, Fuel and Water Filters and Crankcase Ventilators lengthen the life of engines, decrease maintenance, cut repair bills and increase mileage between overhauls . . . saving motorists time, trouble and money.



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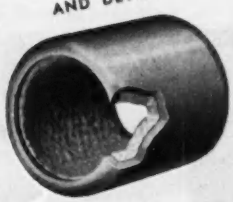

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Testing Techniques To Aid Body Engineers

Based on paper by

H. C. JOHNSON
General Motors Corp.

This paper will be printed in full in SAE Quarterly Transactions

SINCE theoretical and empirical engineering formulas do not always apply to automobile body structures, reliance must be put on structural testing to supplement available information. In this paper is presented a technique for complete car structural and road testing in conjunction with body tests for such purposes as: aiding development of experimental body designs, assisting in the standardization of quality control methods, solving special problems in fabrication, furthering the improvement of body-frame unit structural efficiency, and investigating the use of new materials.

The tests covered by the author are: chassis-frame structural, body-chassis frame unit structural, body-chassis frame unit distortion, complete car structural, durability road, and rollover. (Paper, "Stress Testing Methods in Body Structures," was presented at SAE National Passenger Car, Body, & Materials Meeting, Detroit, March 5, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

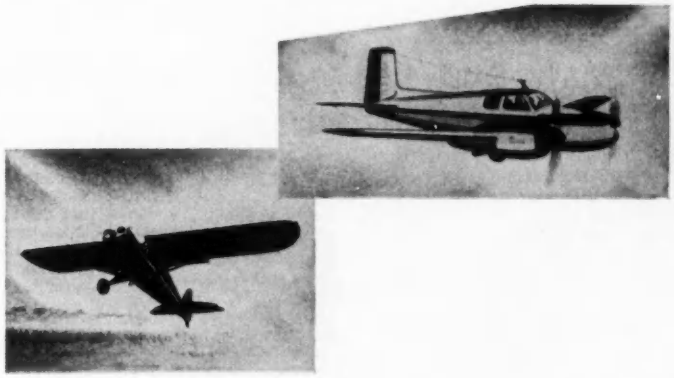
Use of Alcohol For High Octane Pep

Based on paper by

JAMES C. PORTER
Northern Regional Research Laboratory

IF high octane fuels were used in high compression engines only when needed, it would result in the saving of these premium fuels and make possible use of fuels available at the present time. Dual fuel carburetion promises to do just this, since it would provide full octane value near or at full throttle, namely, during acceleration and hill climbing.

Laboratory and road tests of a 10:1 engine equipped with dual carburetion and using various fuels gave most favorable results for overall mpg of total fuel and for the consumption ratio of high and low octane fuels. And it showed that use of alcohol or an alcohol-gasoline blend makes available an



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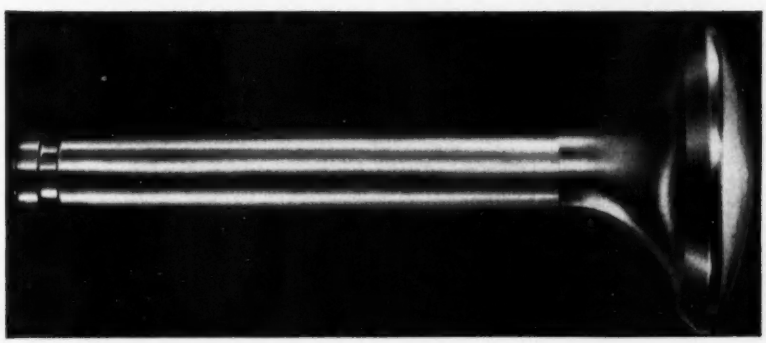

additional source of high octane fuel.

The paper presents a series of charts showing results of dual carburetion road and laboratory tests in full detail. (Paper, "Alcohol as a High Octane Fuel," was presented at SAE Bradley University—Student Branch, Peoria, Dec. 12, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Sports Car Injects New Note

Based on paper by

RICHARD F. BAIRD

Chrysler Corp.

SINCE World War II there has been a growing interest in many phases of the automobile. Most noticeable is the rebirth of the sports car event as a crowd-gatherer and the sports car itself as a new note in American automobiles.

With the entry of American built and powered cars in the 1950 and 1951 LeMans races, and with more professional and amateur production of competitive machines in this country, it is evident that the sports car has again arrived. The increase in their number, both imported and domestic, could color the thinking of the thousands who attended the races at Watkins Glen and elsewhere.

The keynote of the sports car is winning performance, while comfort and cubic capacity are the requisites of the family car, thus two opposing schools of thought have been established. What we are likely to see is the full-fendered sports touring model taking precedence over the cycle-fendered, hard riding competition car tailored primarily for the racing circuit. (Paper, "The Demanding Public," was presented at SAE Detroit Section, Junior Panel Meeting on Passenger Car Styling, March 24, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

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These heavy duty, self-propelled combines start their year's work in the grain fields of Texas . . . and follow the harvest north to Montana. That means months of day-in, day-out rough going . . . the kind that tests the strength and cooling characteristics of the radiator. Only the best will stand this type of heavy-duty performance . . . and that's where Yates-American radiators fit into the picture to provide the double-duty cooling for both threshing and propelling. Specify Yates-American radiators as standard equipment on your products . . . write today for full information and descriptive literature.
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Better Mousetraps Still Have to Be Sold

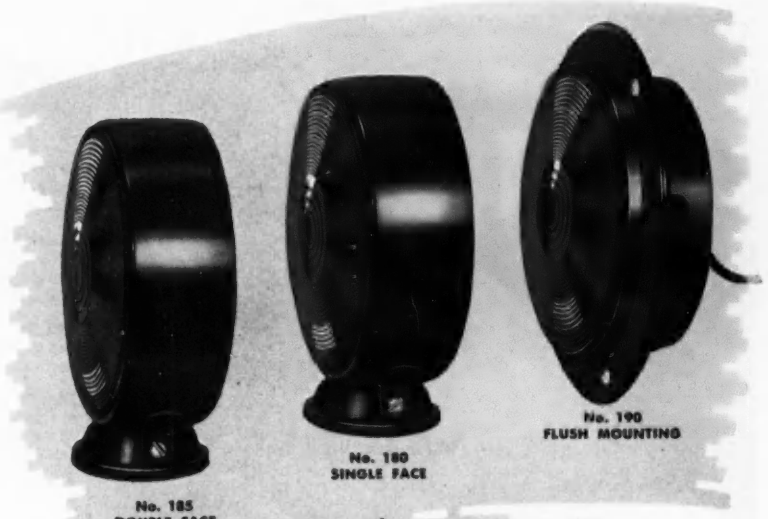
Based on paper by

H. G. SWIGERT

Hyster Co.

THE role the salesman has played in the advance of the earth moving equipment industry is probably overlooked. It is easy to point out the advantages of modern equipment, but it was all new once and people didn't flock to buy it, they had to be sold.

It is a fallacy to believe that if you build a better mousetrap the public will beat a path to your door. That is 105% wrong. It is more accurate to say that if you had the best mousetrap in the world, but were on the wrong corner, your competitor would get the business. The American salesman has had less recognition of his real contribution than anyone in industry. Everything made has to be sold and the more revolutionary the idea the better selling it takes. When improvement of machinery is being discussed, equal consideration should be given to the sale of it. (Keynote Address, presented at SAE Earthmoving Industry Conference, Peoria, Ill., April 9, 1952).



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Students Enter Industry

Continued from Page 92

DONALD M. MULLINS (University of Pittsburgh '52) has joined General Electric Co., Schenectady, N. Y.

THOMAS W. NEWMAN (Michigan College of Mining and Technology '51) is now mechanical engineer for Chris-Craft Corp., Algonac, Mich.

HELEN L. MENTZEL (Oklahoma A and M College '52) is now a test engineer for General Electric Co.

JAMES J. MALLOY (Drexel Institute of Technology '51) is with Minneapolis-Honeywell Regulator Co., Philadelphia, Pa., as designer.

EDGAR D. JEFFRES (University of Colorado '52) is a junior engineer for Pacific Intermountain Express, Denver, Colo.

J. BRUCE INGOLD (Purdue University '52) has joined Bendix Products Division of Bendix Aviation Corp., South Bend, Ind.

ADAM L. REA (Indiana Technical College '51) is with Babcock and Wilcox Co., Barberton, Ohio, as junior engineer.

LAWRENCE B. WADE (Northrop Aeronautical Institute '51) is a weight analyst for Hiller Helicopters, Inc., Palo Alto, Calif.

ROBERT L. JONES (Purdue University '50) is with GMC Allison Division, Indianapolis, Ind., as test engineer.

FRANK K. YOUNG (Gonzaga University '52) is with Popular and Special Nut Co., Ferndale, Mich.

DAVID A. PHILIPP (Northrop Aeronautical Institute '52) is with Hughes Aircraft Co., Culver City, Calif., as engineer-draftsman.

TRACY W. LUNT, JR., (Northrop Aeronautical Institute '51) is a drafting engineer for Coleman Engineering Co. in Culver City, Calif.

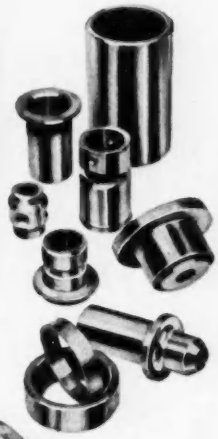
WILLIAM J. DEGNAN, JR., (Northrop Aeronautical Institute '51) has joined Northrop Aircraft, Inc., Hawthorne, Calif., as engineering draftsman.

CHARLES E. STILES (University of Oklahoma '52) is a test engineer for General Electric Co., Schenectady, N. Y.

ROBERT D. SHORT (University of Pittsburgh '52) is now with the Radio Corp. of America, Camden, N. J.

NEIL H. PERKINS (Parks College '52) is a second lieutenant in the U. S. Air Force.

DONALD E. PAULY (Rensselaer Poly-



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BRONZE BACK
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—powder metallurgy

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Students Enter Industry

Continued

technic Institute '51) is in U. S. Navy aboard the destroyer U. S. S. Shea. Ensign Pauly is communications and anti-submarine warfare officer.

RANDOLPH L. DODD (Utah State Agricultural College '51) is a lieutenant in the U. S. Air Force stationed at Langley Air Force Base, Va.

U. V. JOHNSTON (Southern Methodist University '50) has been recalled to active duty by the Marine Corps Reserve and is serving in Korea.

TIMOLEON G. ARGYROPOULOS (McGill University '51) is now with Bristol Airplane Engines (Eastern), Ltd., Montreal, P. Q.

WILLIAM E. BACHMAN (Bradley University '51) has joined Bendix Products Division of Bendix Aviation Corp., South Bend, Ind., as a junior engineer.

ROBERT BANKS (Fenn College '51) is a draftsman for Babcock and Wilson Co., Cleveland, Ohio.

CLAUDE C. BEALS, JR., (Ohio State University '51) is in training with Diamond Power Specialty Corp., Lancaster, Ohio.

FRED N. BREES (University of Oklahoma '51) has joined Boeing Airplane Co., Seattle, Wash., as a junior engineer.

JOHN W. BROOKS (University of Michigan '51) is with Baldwin-Lima-Hamilton Corp. in Lima, Ohio, as naval engineer.

CLARENCE S. BROWN, JR., (San Diego State College '51) is a sales engineer for Swedlow Plastics Co., Los Angeles, Calif.

CHARLES M. ATTERBURY (Illinois Institute of Technology '51) is now test engineer for R. T. Crane Co., Chicago.

EDWARD H. KUSIAK (University of Massachusetts '50) is with Hamilton Standard Division of United Aircraft Corp., East Hartford, Conn., as design layout engineer.

JOSEPH V. KRASON (Rensselaer Polytechnic Institute '51) is chief engineer of Cro-Plate Co., Inc., Hartford, Conn.

JOSEPH S. COMBER (California State Polytechnic College '51) has joined Westinghouse Electric Corp. in Pittsburgh, Pa.

ABRAHAM TUCKER (New York University '51) is a transmission engineer at the helicopter division of Bell Aircraft Corp., Fort Worth, Texas.

ROBERT O. NEFF (Illinois Institute of Technology '52) has joined Mara-

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Technical Service Data Sheet

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Tests prove that the new Moraine-400 engine bearings are almost unbelievably tough . . . that they have *six* to *ten* times the life of conventional automotive engine bearings. For example—Moraine-400 bearings were still in good condition after *750* hours of endurance tests—the same tests that cause conventional bearings to fail within *100* hours.

In other tests we reduced the bearing area by one-half, thereby more than doubling the load. Placed in a high-compression automobile engine and run 100 hours at 4300 r.p.m., Moraine-400 bearings were in excellent condition at the end of this tough test.

Overall bearing length ceases to be a limiting factor in automotive engine design when Moraine-400 is used. A shaft of sufficient diameter and rigidity to handle the torque, and journals long enough for good oil-hole design, are all that are required for long bearing life. Moraine-400 operates satisfactorily on both Tocco-hardened and oil-hardened shafts and is outstanding in embedability, conformability and corrosion resistance.

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MORAINE PRODUCTS
DIVISION OF GENERAL MOTORS
DAYTON, OHIO

Moraine-400 is made by the manufacturers of the famous Durex-100 bearings — now used as original equipment on many of the nation's finest cars and trucks.

Students Enter Industry

Continued

thon Corp., Menasha, Wis., as plant engineering assistant.

NED C. BRUNER (University of Colorado '52) is plant engineer for United Carbon Co., Aransas Pass, Texas.

TOM L. BURCHAM (Purdue University '52) is a trainee with Caterpillar Tractor Co., Peoria, Ill.

LESTER F. BURDORFF (Purdue University '50) is with Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio, as experimental test engineer.

MARTIN S. BLACKMAN (University of Southern California '52) is research analyst for North American Aviation, Inc., Downey, Calif.

ERIC D. BROWN (University of Wisconsin '49) has received his master's degree from the University of Wisconsin and is now in the engineering department of Nordberg Mfg. Co., Milwaukee, Wis.

WALTER E. BARTHEL (University of Wisconsin '52) is a draftsman for Northrop Aircraft, Inc., Hawthorne, Calif.

EMERY E. ECKERT (Cal-Aero Technical Institute '51) is a junior engineer for Boeing Airplane Co., Seattle, Wash.

CHARLES M. REID (Cal-Aero Technical Institute '51) has joined Century Engineers, Inc., Burbank, Calif., as draftsman.

JOHN W. BROOKS (University of Michigan '51) is a process engineer for Remington Arms Co., Inc., at Lake City Arsenal, Independence, Mo.

GORDON WANG (Michigan State College '50) is with Burroughs Adding Machine Co., Detroit, as development engineer.

JOSEPH G. FEDOR (Bradley University '52) is with the State of Illinois Department of Highways.

HENRY TAT CHING YU (University of Wisconsin '52) is a product tester for the farm tractor engine department of International Harvester Co., Chicago, while doing graduate work in evening classes at Illinois Institute of Technology.

ARTHUR A. ZERRY (Parks College '52) is a junior flight test liaison engineer for Boeing Airplane Co. in Wichita, Kans.

JOHN B. WHITE (Ohio State University '52) has joined Pittsburgh Plate Glass Co., Ford City, Pa., as junior industrial engineer.

CLYDE C. WILCOX (Tri-State College '52) is metallurgical engineer for the aircraft division of Willys-Overland Motors, Inc., Anderson, Ind.

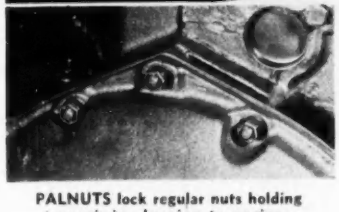
EARL R. WILSON (University of Oklahoma '52) is at the Ordnance Aerophysics Laboratory of Consolidated Vultee Aircraft Corp., Daingerfield, Texas, as test engineer.

WALTER C. ROBERTSON (Texas A and M College '52) is a field engineer trainee for the Square D Co., Milwaukee, Wis.

DON L. BUCKEY (Aeronautical University '52) is with the aeronautical design department of McDonnell Aircraft Corp., St. Louis, Mo.

DONALD W. HOWELL (Illinois Institute of Technology '52) is with Barber-Colman Co., Rockford, Ill., as me-

Absolute security for bolted assemblies —at low cost!



PALNUTS lock regular nuts holding transmission housing to engine.

PALNUTS lock regular nuts on support for drive shaft tube.

WHEREVER a bolted assembly **must** stay tight in service, add a Regular Type PALNUT Locknut on top of the ordinary nut. Here are the advantages:

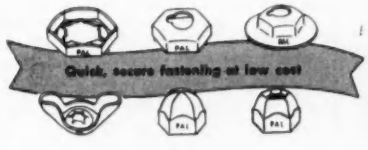
- **Holds ordinary nut and bolt to original tightness, under severest vibration**
- **Easy, fast assembly with hand or power drivers**
- **Ordinary nut and PALNUT cost less than most other locknuts**
- **Requires no more space**
- **Unaffected by heat or oil**
- **No damage to nut or nut seat**
- **May be removed and re-used**

The unfailing security of PALNUT double-locking action is proved by the increasing use on connecting rods, brake parts, exhaust manifolds, body hold down, front and rear engine mountings, etc. Send details of your assembly for samples and data.

Note: This ad describes the Regular Type PALNUT used for heavy loads and vibration. Many other types available for use as load-carrying nuts for low-cost assembly of moulding, medallions, nameplates, etc.

Write for samples and data on Regular Type PALNUT Lock Nuts

The Palnut Company, 70 Cordier St., Irvington 11, N. J.
Detroit: 730 West Eight Mile Road



PALNUT
TRADEMARK
LOCK NUTS

Aerophysicists, Designers, Engineers

YOUR IDEAS WILL COUNT AT NORTH AMERICAN

North American encourages advanced thinking, because they know looking ahead is the only way to maintain leadership in the aviation industry. That's why North American needs men of vision. If you like hard thinking and would like to work for a company that will make the most of your ideas, you'll find real career opportunities at North American. North American offers you many extra benefits, too.

North American Extras—

Salaries commensurate with ability and experience • Paid vacations • A growing organization • Complete employee service program • Cost of living bonuses • Six paid holidays a year • Finest facilities and equipment • Excellent opportunities for advancement • Group insurance including family plan • Paid sick leave • Transportation and moving allowances • Educational refund program • Low-cost group health (including family) and accident and life insurance • A company 24 years young.

Write Today

Please write us for complete information on career opportunities at North American. Include a summary of your education, background and experience.

IS YOUR FIELD LISTED HERE ?

Airborne Electronic Equipment
Equipment Flight Tests
Precision Instruments
Automatic Controls
Propulsion Systems
Servo-Mechanisms
Airframe Studies
Radar Devices
Instrumentation
Micro Wave Techniques
Metallurgical
Electroplating
Engineering Planning

NORTH AMERICAN AVIATION, INC.

Aerophysics, Electro-Mechanical Research Division

Dept. 12, Personnel Section,
12214 Lakewood Blvd., Downey, California

North American Has Built More Airplanes Than Any Other Company In The World

Students Enter Industry

Continued

chanical engineer on aircraft controls development.

FRED T. SCHICK (Illinois Institute of Technology '52) is assistant engineer for McDonnell Aircraft Corp., St. Louis, Mo.

JOHN R. FOLKROD (University of Illinois '52) has joined International Harvester Co., Chicago, as core maker.

SIRAGAN MARDEROSIAN (Detroit Institute of Technology '51) is a mechanical engineer with Brown-Hutchinson Iron Works, Detroit, Mich.

MARK J. O'CONNELL (Michigan State College '51) is with Bell Aircraft Corp., Buffalo, N. Y., as design engineer—but, O'Connell adds, he is "in danger of being drafted!!"

CHARLES M. NEUGEBAUER (Illinois Institute of Technology '52) is a junior designer for Bendix Aviation Corp., South Bend, Ind.

ROBERT G. SHEEHAN (Illinois Institute of Technology '52) is an officer candidate at the U. S. Naval School, Newport, R. I.

JAMES E. FEENEY (Aeronautical University '52) has joined McDonnell Aircraft Corp., St. Louis, Mo.

BRUCE R. AUBIN (Parks College '51) is now a junior engineer with Canadian Car and Foundry Co., Ltd., at Fort William, Ont.

STEVE CSONKA (Fenn College '51) is now with Timms Spring Co., Elyria, Ohio, as junior engineer.

NORMAN L. WETTER (Rensselaer Polytechnic Institute '51) has joined Harrison Radiator Division of General Motors Corp. as junior tool designer.

WILLIAM S. FOWLER (California State Polytechnic College '51) is production engineer for Varian Associates, San Carlos, Calif.

GARY M. DAVIES (West Coast University '51) is an engineering trainee for Clayton Mfg. Co. in Elmonte, Calif.

RICHARD F. McGILL (General Motors Institute '51) is now in Antwerp, Belgium, as assistant public relations manager for General Motors Continental.

LLOYD J. McINTYRE (University of Toronto '51) is with Construction Equipment Co., Ltd., Toronto, in the rentals and sales department.

SAMUEL B. CRIPE (Purdue University '50) is now serving in Korea with the U. S. Navy.

S. JAGADISH CHANDRAN (Parks College '51) has returned to India and is special assistant with the Air Transport Directorate of the Department of Civil Aviation in New Delhi.

ROBERT E. WIENEKE (Northrop Aeronautical Institute '51) is now with North American Aviation, Inc., Downey, Calif., as engineering designer.

DAVID PATERSON, JR. (Lawrence Institute of Technology '51) is now a captain in the U. S. Air Force, stationed at Donaldson Air Force Base, Greenville, S. C.

GERHARDT E. LICHTFUSS (Valparaiso University '51) is serving with the Army's 101st Airborne Division.

WILLIAM H. WHITLEY (San Diego State College '51) is a junior engineer with Consolidated Vultee Aircraft Co., San Diego, Calif.

JOHN D. McCARTHY (Manhattan College '51) is now in the U. S. Navy.

WILLIAM J. BIRK (California State Polytechnic College '51) is a design engineer for American Pipe and Steel Co., Alhambra, Calif.

RAYMOND L. ADDINGTON (Cal-Aero Technical Institute '51) has joined Bendix Aviation Corp. in North Hollywood, Calif., as draftsman.

JAMES MASKELL (McGill University '51) is now service engineer for Canadair, Ltd., St. Laurent, P. Q.

JOHN W. FULTON (Rensselaer Polytechnic Institute '51) is at Wright Air Development Center, Dayton, Ohio, as assistant project engineer.

JAMES A. CRABTREE (Michigan State College '51) is with the Spring Division of Eaton Mfg. Co., Detroit.

DANIEL A. FISHER (Northrop Aeronautical Institute '51) has been recalled to active duty by the U. S. Naval Reserve. He is now stationed at the United States Naval Air Missile Test Center in California.

DON A. MEYER (Purdue University '51) is an ensign in the U. S. Navy. He is stationed on the U.S.S. Picking.

NORBERT R. BALZER (Fenn College '51) is in the production control department of Ohio Crankshaft Co., Cleveland, Ohio.

DAVID E. CROCKETT (Wayne University '51) has joined Creative Services, Inc., Detroit, as a writer and technical editor.

WILRED C. FREDERIKSEN (McGill University '51) is engineer in training with Canadian General Electric Co., Ltd., Peterborough, Ont.

CHARLES A. DAVIDSON (Virginia Polytechnic Institute '51) is director of safety and cost engineer of Lemmon Transport Co., Inc., Marion, Ga.

New Members Qualified

These applicants qualified for admission to the Society between June 10, 1952 and July 10, 1952. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

Herbert Bubeck (M), Lester C. Malone (M).

British Columbia Section

Gunnar Edwin Baardsen (A), M. J. Nugent (A).

Buffalo Section

Edwin V. Bishop (M), Edward Angus Brown (J), Chester Raymond Haig, Jr. (M), Harold I. Johnson (M), H. Vaughn Lowther (J), Fred J. Vollmer (M).

Canadian Section

Earl Holden Fisher (M), Ewart T. Griffith (M), Ilmar Manner (A), Arthur L. Thomas (M).

Central Illinois Section

Eugene Brookhouzen (M), H. Dale Clark (J), Murl W. Clark (J), Edward James Guthmann (J), Jay J. Murphy (J), Theodore L. Oberle (M), Cloyd W. Richards (A), Robert Irvan Wilson (J).

Chicago Section

Andrew Alfred Affrunti (J), Richard S. Halladay (A), Clifford N. Hinkle (M), Joseph M. Husvar (M), Dr. Klaus Karde (M), Raymond C. McCullough (A), John K. Nemeth (J), Stanley Z. Siwek (M), Roy W. Troxel Jr. (A).

Cincinnati Section

Warren M. Custer (A).

Cleveland Section

Thomas F. Cockrem (M), Otto H. Eberlein (M), John E. Ehlert (A), R. Van Dyke Firth, Sr. (M), Joseph R. Gensheimer (M), Edwin H. Horne (A), Frank C. Kreitler, Jr. (M), Raymond H. Ptak (M), Herman Douglas Rowe (M), Ernest C. Sweigert (J), Charles S. Tennant (M), Russell D. Whitmore (A).

Colorado Group

Ernest M. Martin (M).

Dayton Section

Charles E. Ryan, Jr. (J).

Detroit Section

D. C. Apps (M), Bernhard R. Bermann (M), Arthur C. Blauwaert (J), Donald Kendall Brooks (J), George Francis Butts (J), Robert W. Chamberlin (A), C. Dwight Dilloway (A), Herman W. Fagert (M), William M. Fairhurst (A), Sally Ann Farquhar (J), George P. Fenstermacher (J), Joseph C. Fields (A), J. Earl Fraser (A), E. E. Goepfrich (A), Kenneth W. Gordon (M), Norris L. Haight (J), Ralph H. Hixenbaugh (M), Arthur Vaun Kossel (J), Richard E. Krafve (A), Harold C. Leiphart (M), Alan Carlyle Lewis (J), Clifford G. Likes (M), David Alan Martens (J), Leslie A. Mason (M), Duncan McPherson (J), Marshall Edward Munroe, Jr. (A), John D. Nothstine (M), William Ernest Oliver (J), William J. Pierce (J), Phillip George Plevek (J), Robert J. Pocock (M), Robert Earl Ringe (J), Richard Vaughan Rogers (M), John R. Rubner (A), Carl F. Schorn (M), Perry Swartz (J), Carl S. Taylor (J), Guy Boyd Vass (A), Paul W. Winkelmann (M), Clifford C. Wrigley (M).

Hawaii Section

Eugene Richard Fitch (A).

Indiana Section

James A. Hardy (M), Norman W. Kimmel (M), David C. Wynn (A).

Kansas City Section

William Henry Harper (M), S. L. Higginbottom (M).

Metropolitan Section

Albert H. Beaufrere (M), William G. Beiswinger (M), Michael Cutler (J), William John Flach (J), William D. Kent (M), Charles R. Limbacher (J), Joseph A. Li Puma (A), Eric Schwarz (M), Frank P. Suk (M), Eugene Williamson (A), Ernest Victor Wilson (J).

Mid-Continent Section

William H. Little (A).

Mid-Michigan Section

Ross W. Buchanan (M), Arthur Huntingdon Elbers (J), Daniel M. Fullmer (M), Harold L. Howard (M), Dwight D. Hughes (A), Kenneth K. King (M).

Milwaukee Section

Arthur G. Brown (M), Clarence Line Flessate (J), Russell Warren Henke (J), John W. Lendved (M).

Mohawk-Hudson Group

Stanley H. Proffitt (M).

Continued on Page 134

Frankly, working at North American requires hard thinking and plenty of vision. Because North American always works in the future. Yet, if you are interested in advanced thinking, if you'd like to work on the planes that will make tomorrow's aviation history, you'll like working at North American. North American offers these extra benefits, too.

North American Extras—

Salaries commensurate with ability and experience • Paid vacations • A growing organization • Complete employee service program • Cost of living bonuses • Six paid holidays a year • Finest facilities and equipment • Excellent opportunities for advancement • Group insurance including family plan • Sick leave time off • Transportation and moving allowances • Employees Credit Union • Educational refund program • Low-cost group health (including family) and accident and life insurance • A company 24 years young.

Write Today

Please write us for complete information on career opportunities at North American. Include a summary of your education, background and experience.

CHECK THESE OPPORTUNITIES AT North American

- Aerodynamicists
- Stress Engineers
- Aircraft Designers and Draftsmen
- Specialists in all fields of aircraft engineering
- Recent engineering graduates
- Engineers with skills adaptable to aircraft engineering

NORTH AMERICAN AVIATION, INC.

Dept. 11, Engineering Personnel Office
Los Angeles International Airport
Los Angeles 45, Calif.; Columbus 16, Ohio

North American Has Built More Airplanes Than Any Other Company In The World

For GREATER SERVICE ECONOMY

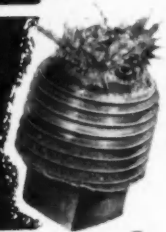
LISLE Magnetic DRAIN PLUGS

You can cut the cost of your service guarantee by installing Lisle Plugs as original equipment in crankcase, transmission, overdrive and rear axle.

A strong, permanent magnet in each Lisle Plug attracts and holds particles that flake off moving parts and circulate in lubricants. Removal of this abrasive metal greatly reduces wear to vital moving parts.

Replace Ordinary Plugs with LISLE PLUGS

To Remove IRON and STEEL Particles from Oil



YOUR *sample* LISLE PLUGS *will be sent to you* FREE *for testing. Just state size and type of plug desired.*

LISLE Corporation

CLARINDA, IOWA

New Members Qualified

Continued

Montreal Section

Gaston Beauchamp (J), Steve Benchik (A), Abraham Esar (A), Gordon R. McGregor (M), Barstow Harding Miller (M), Frank Potts (M).

New England Section

Larry E. Shaffer, Jr. (J), Lawrence C. Simonetti (A), Maurice H. Weiner (A).

Northern California Section

Jack Arnold Bert (M), Granvil E. Crawford (SM), Edgar F. Giesselmann (M), Robert J. Matthews (J).

Northwest Section

Joseph Daniels (A).

Oregon Section

Dorsey E. Belt (A), Don M. McGuire (A), Claude W. Shumete (A).

Philadelphia Section

Bruno D'Angelo (M), Karl F. Green (J), John S. Hazley (J), Leonard Francis Leone (M), Charles B. Moore (J), Salvatore John Straniti (M).

St. Louis Section

B. W. DeLong (M), Stanley T. Dueker (M).

San Diego Section

Joseph R. Wilkes (M).

Southern California Section

Griffith Borgeson (A), Russell Dare Guy (A), Eugene C. Kimball (A), Earl Edward Lund (J), John K. Morris (M), Dudley J. Shrimpton (M).

Southern New England Section

Edmund Hoskins Case (J), Henry Clifford Morton (M), Edgar C. Shoup, Jr. (M), Peter Joseph Stelmat (M).

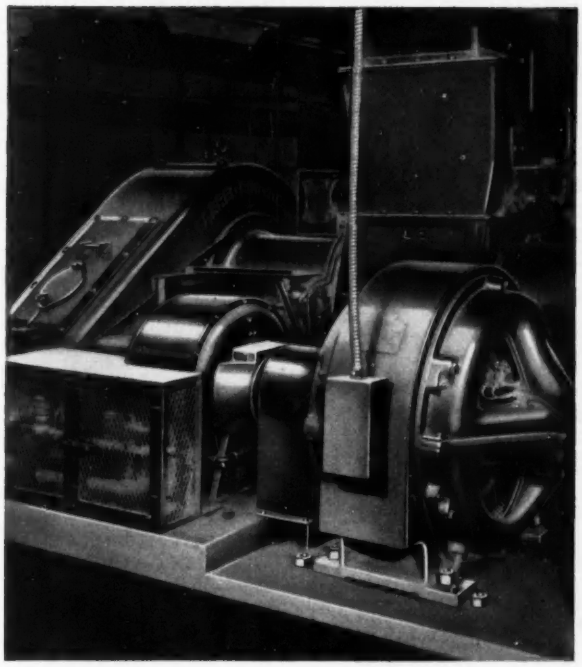
Spokane Intermountain Section

Lewis J. McBride (M).

Texas Section

Warren N. White (M).

Continued on Page 136



Model 8W Dynamatic Water-Cooled Coupling used to obtain adjustable speed from 200 HP, 720 RPM synchronous motor to drive a Plasticator carrying rubber from a Banbury Mixer in the plant of a large tire manufacturer.

DYNAMATIC®

WATER-COOLED POWER COUPLINGS

WIDE SPEED RANGE

INSTANTANEOUS RESPONSE

ACCURATE SPEED CONTROL

STEPLESS SPEED ADJUSTMENT

SMOOTH TORQUE TRANSMISSION

TOTALLY ENCLOSED

SIMPLE • QUIET

COMPACT • EFFICIENT

Provide Adjustable Speed Drive with any AC Motor

The Dynamatic Coupling transmits rotation from a driving to a driven member without mechanical contact—with stepless adjustable control and with almost instantaneous response. It is a simple and effective method of providing adjustable speed from a constant speed source (or vice versa) with full-torque starts. The addition of an eddy-current brake will provide smooth controlled deceleration.

Effective water-in-the-gap cooling makes possible large capacity in small space, and the construction provides complete protection of the interior of the coupling against atmospheric impurities.

A standard range of sizes of Dynamatic Water-Cooled Couplings is available for transmitting torques of 50 pounds feet up to approximately 5,000 pounds feet. Many other sizes up to and including single units for handling 200,000 pounds feet of torque are in service and units of larger capacity can be built to order.

Write for Illustrated Bulletin WC-1

DYNAMATIC® CORPORATION • KENOSHA WISCONSIN

Subsidiary of **EATON MANUFACTURING COMPANY**, Cleveland, Ohio

Dynamometers • Oil Well Draw-Works Brakes • Adjustable-Speed Couplings • Eddy-Current Brakes
Ajusto-Spedes • Shovel Clutches • Press Drives • Lift Truck Clutches • Electronic Controls

New Members Qualified

Continued

Twin City Section

Forrest Roderick Grimm (J), Henry A. Halgren (M), Fred C. Nielsen (M), Eugene P. O'Connor (A), Hertel A. Sandven (M).

Virginia Section

Henry Walter McAllister (A).

Washington Section

Major Frederick Graham Robinson (FM).

Western Michigan Section

Norman Louis Bonema (J), Arling H. Jensen (M), Erwin W. Knoth (A).

Wichita Section

Monroe F. Kent (M).

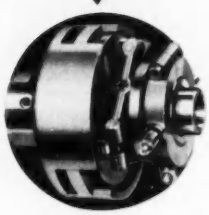
Outside Section Territory

C. S. Lagergren (M), De Alton Martin (A), Kenneth E. Schlabach (J), Frank B. Wynne (M).

Foreign

Alan Richard Bassett (FM), England; Thomas Anthony Campobasso (FM), Germany; Henry R. Perkins (FM), England; Allen H. Richards (FM), Saudi-Arabia; Gordon Stuart Sharpe (FM), England.

This Sand-and-Cinder Spreader



Makes Highways Better Ways

Highway Equipment Company, of Cedar Rapids, Iowa, has developed a complete line of spreaders that contribute toward better-built highways. ROCKFORD CLUTCHES help regulate the spreading mechanism in the NEW LEADER Sand-Cinder & Chip spreader shown above. Let ROCKFORD clutch engineers help design better power transmission controls for your engine-driven equipment.

ROCKFORD CLUTCH DIVISION BORG-WARNER
316 Catherine Street, Rockford, Illinois, U.S.A.

B-W ENGINEERING MAKES IT WORK

B-W PRODUCTION MAKES IT AVAILABLE

ENGINEERING BULLETIN SENT ON REQUEST

ROCKFORD CLUTCHES

Applications Received

The applications for membership received between June 10, 1952 and July 10, 1952 are listed below.

Atlanta Group

George Dwelle Elyea.

Canadian Section

Richard Austin Evans, Alexander James Szabo, John Henry Wexall.

Central Illinois Section

Howard T. Thistlewood.

Chicago Section

Lawrence E. Donahue, William F. Gehle, William C. Mellender, Paul Otto Nelson, Peter Panayot Novas, Lester H. Thorson, Charles W. Wulff.

Cincinnati Section

William Marshall Dunn, Robert Kirkpatrick Welch.

Cleveland Section

Frank J. Ambrose, James Robert Jeromson, Jr., Everett L. Jones, Jr., Howard Otto Mielke, Percy H. Neville, Henry Palange, James Ernest Robinson, Eugene Rogowski, D. H. Ruhnke.

Continued on Page 138

On the World's Finest Airliners

Bendix IS FIRST IN FUEL METERING, LEADER IN LANDING GEAR

On the great ships that fly the commercial air ways of the world, you will invariably find Bendix fuel metering equipment and landing gear speeding service and adding safety from take-off to landings.

The rigid performance standards set by airline operators and plane builders alike permit no compromise with quality.

That's why Bendix carburetion, direct fuel injection, shock absorbing struts, wheels and brakes are the choice wherever planes fly.

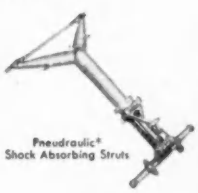
Bendix is justifiably proud of this overwhelming endorsement of its products and the part these vital components play in helping American aviation lead the world.

BENDIX • PRODUCTS DIVISION • SOUTH BEND

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

Bendix AVIATION CORPORATION

Fuel Metering Unit for jet engines



Pneudraulic* Shock Absorbing Struts

Speed-Density Fuel Metering Unit

Stromberg* Injection Carburetors

Segmented Rotor Brakes

Landing Gear Wheels for all types of airplanes

Bendix Products Division

*REG. U.S. PAT. OFF.

IF NUTS HAD
"TIME" TAGS
INSTEAD
OF
JUST
PRICE
TAGS
2 MINUTES
6 MINUTES
...you'd buy Midland Weld Nuts!
It may pay you to buy "on time" —the time it takes to assemble your product. And if you're troubled by "blind spots," hard-to-get-at bolts and nuts,
better investigate . . .
MIDLAND
WELD NUT
The MIDLAND STEEL PRODUCTS COMPANY
6660 Mt. Elliott Ave. • Detroit 11, Michigan
Export Department: 38 Pearl St., New York, N. Y.
MANUFACTURERS OF:
AUTOMOBILE AND TRUCK FRAMES
AIR AND VACUUM POWER BRAKES
AIR & ELECTRO-PNEUMATIC DOOR CONTROLS

Applications Received

Continued

Colorado Group

Charles John Nassimbene.

Dayton Section

Ralph Burnett Clark, Jack W. Dern, Edward Francis Mersereau.

Detroit Section

Donald W. Bain, Charles Donald Blair, Thomas J. Bischoff, James Albert Crabtree, N. Crisman, John M. Hastings, Howard J. Howerth, James Richard Landis, Kenneth L. Long, James C. McDonald, Robert E. Owen, James George Pauly, George Morrison Peden, Ivan N. Schatzka, Herbert E. Smith, Vernard Taylor, Robert Gordon Wrinn, Emory Newton Yount.

Indiana Section

Robert William Bachmann, Howard Eugene Coe, Milton D. Parker.

Kansas City Section

John R. Campbell, George Michael Francis Carter, J. E. Creason, Robert M. Hatcher, Jr., William E. Spreen, Jr., Harvey L. Wise, Harold F. Wiseman.

Metropolitan Section

Alan Broder, Warren H. Brodie, Donald M. Brown, Henry Cushman, Brad Fidell, Sheldon Fox, Calvin B. Huntoon, William D. Jameson, Stevens C. Sperlins.

Mid-Michigan Section

Donovan E. Lusk.

Milwaukee Section

T. E. DuBrucq, Robert George Matters, T. G. Shedore, Robert W. Strehlow.

Montreal Section

Timoleon Argyropoulos, George Bisson, Norman Paterson Danforth.

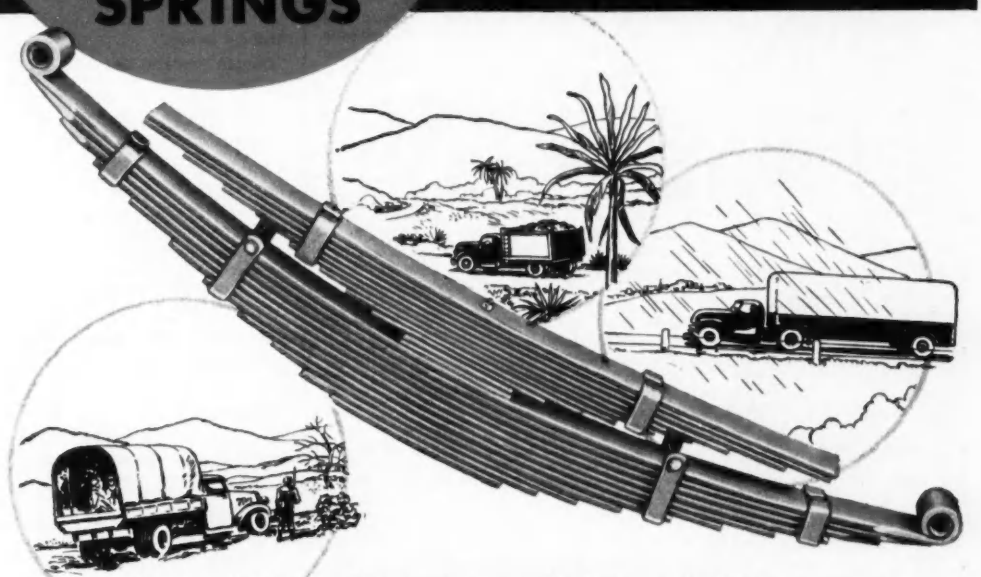
New England Section

Lynn W. Biwer, Edward Thomas Giblin, Paul A. Henneforth, Arthur C. Herrington.

Continued on Page 140

DSP Leaf SPRINGS

ON TRUCKS—THE WORLD OVER—THE TOUGHEST JOBS PROVE THESE SPRINGS CAN "TAKE IT"



Army trucks operating in Korea's rugged terrain. Construction trucks on the Pan-American Highway. Trailers hauling enormous payloads from coast to coast in our own country.

On much of this equipment, springs, engineered to stand the punishment of the most demanding conditions, are supplied by DSP. Makers of America's heavy trucks use DSP Leaf Springs as original equipment in some, or all, of their current production; for both civilian and military use.

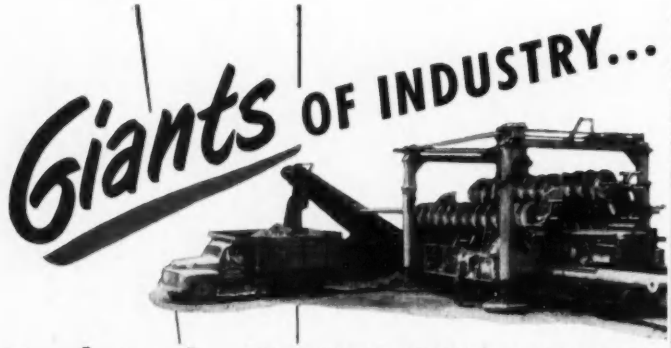
DSP's Automotive Division *SPECIALIZES* in this most important product . . . with its engineering, research, and production facilities directed toward one objective—the design and production of better leaf springs.

Since 1904... ORIGINAL EQUIPMENT ON CARS, TRUCKS, CABS, BUSES, TRAILERS

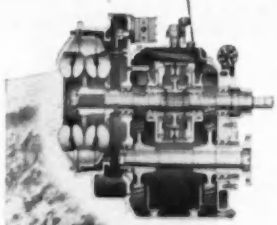
DETROIT STEEL PRODUCTS COMPANY

Automotive Division

2250 E. GRAND BLVD., DETROIT 11, MICHIGAN



Exploit the "TWILIGHT ZONE"



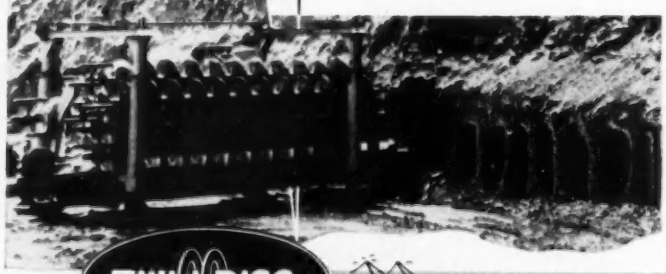
When Compton Inc., Clarksburg, W. Va., developed its huge new 50-ton Compton Coal Auger, a Twin Disc Model 220 Hydraulic Coupling Reverse and Reduction Gear fitted the requirements for a shock-cushioned, quick reversing unit.

Combining two of Twin Disc's successful products—the heavy-duty, shock-absorbing Hydraulic Coupling, and the heavy-duty Reverse and Reduction Gear—the drive has been pronounced "highly satisfactory" by Compton officials, after prolonged production service.

The Auger cuts coal out of walls which heretofore were not exploitable—at such places as the barrier pillars between strip workings and old underground workings . . . the "Twilight Zone". Tests prove that it will repay its cost in a few months.

Such success in providing "the right connection" since World War I, plus the completeness of its line, plus an unmatched service system, have combined to make Twin Disc the world's largest manufacturer of industrial friction and fluid drives.

Hard-cutting, quick-stopping and reversing of this 52-inch—Model 56 Compton Coal Auger requires tough drive links—Twin Disc of course. Reaching 200' into the veins, it digs up to 700 tons per day.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

Built for a Long Life . . .
Backed for a Lifetime

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin · HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND · DALLAS · DETROIT · LOS ANGELES · NEWARK · NEW ORLEANS · SEATTLE · TULSA

Applications Received
Continued

Northern California Section

Ted Brown, Robert Henri Fischer, Curtis A. Knifsend, Cassius Elston Sewell, Harold E. Wheatley.

Oregon Section

Dick Henry Gripp.

Philadelphia Section

Jerome P. Berliner, Raymond George Frank, J. Howell Goffe, Charles J. Gregorovich, Joseph A. Gunning, George J. Reed, John J. Sheehan, Charles V. Toner, William J. Wear, William R. West.

Pittsburgh Section

Donald Frederic Kendrick.

St. Louis Section

James G. Lewellen.

Southern California Section

Robert E. Barnes, Theodore R. Battema, John E. Crawford, Jr., James I. Detweiler, James Joseph Gartland, Jr., Normand Evan Morgan, Alvin Hugh Murphy, Carl O. West, O. A. Wheelon.

Southern New England Section

Fred John Gross, Jr.

Texas Section

Howard E. Campbell, Robert H. Jones, Owen L. Metcalf, Calvin Frank Meyers, Edward Pollak, Jr., Roy Redmond, William Buck Schell, G. B. Shandley, William C. Steen.

Twin City Section

Lawrence W. Edelmann.

Western Michigan Section

W. A. MacLaurin.

Wichita Section

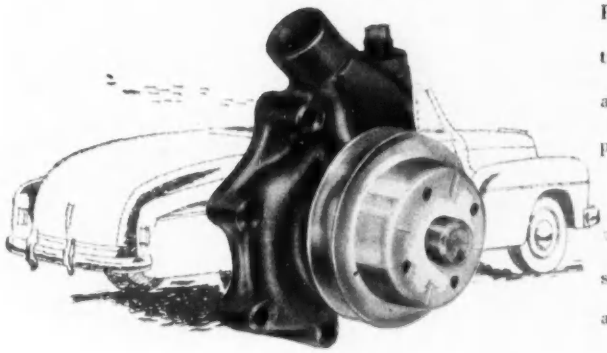
Donald E. Mead.

Outside of Section Territory

Roy E. Barker, Richard Allen Dutton, E. L. Martin, Sydney A. Olsen, James Joseph Somers.

Foreign

Andre Boudineau, France; Ronald William Eggleston, England; Samuel Edward Cecil Soysa, Ceylon; Louis Armand Thaler, France.



PUMPS for the cooling systems of cars, trucks, buses and tractors or pumps for grinding and cutting machines are engineered and precision built by Thompson.

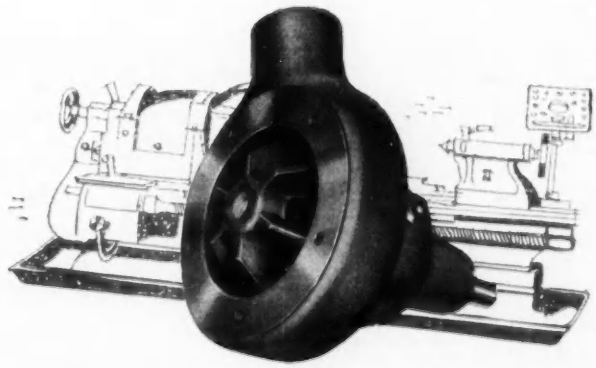
Thompson engineering and Thompson production skills have been sharpened by the production of automotive and aircraft parts for over 50 years.

All the techniques and skills gained in making unbelievably complex items, many made to the closest tolerances, are applied to Thompson automotive and industrial pumps.

For pump performance you can take for granted: *count on* Thompson

This means that every Thompson pump assures maximum performance and dependability.

If you need pumps to keep your product cooled or pumps to cool your engines, write or phone Special Products Division, Thompson Products, Inc., 2196 Clarkwood Rd., Cleveland 3, Ohio. You'll soon learn what leading manufacturers have known for 50 years —*you can count on Thompson.*



Thompson Products, Inc.

SPECIAL PRODUCTS DIVISION

2196 Clarkwood Rd. • Cleveland 3, Ohio

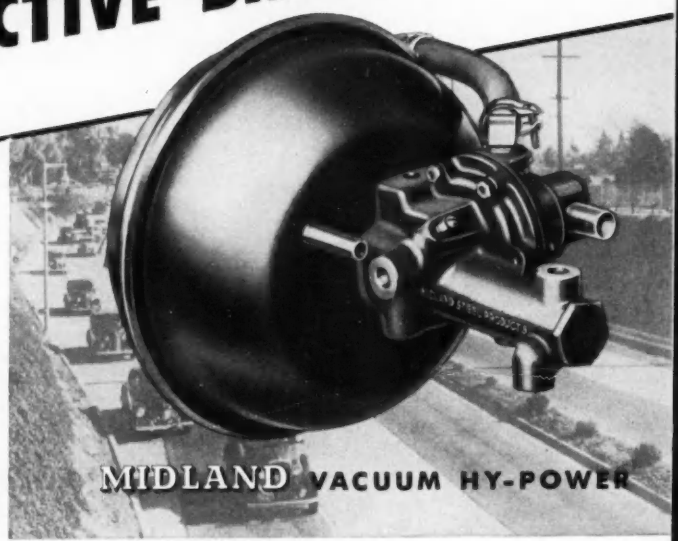
MIDLAND Air Hy-Power — the original air-over-hydraulic power brake system — and still the finest, simplest and most dependable. Brake pedal "feel" permits driver to apply lightning-fast, effective brake action.

Available as original equipment or for replacement in fully engineered kits for practically every truck, bus or trailer.

Those who know Power Brakes Choose Midland

Two Great MIDLAND

POWER BRAKE SYSTEMS MEET TODAY'S NEEDS FOR EFFECTIVE BRAKING



MIDLAND Vacuum Hy-Power— converts ordinary hydraulic brakes into *power brakes* without an air compressor. Simple to install . . . compact . . . rugged construction . . . dependable.

Complete package kits for any size truck from pick-ups to big 3-ton jobs. Now being installed at the rate of over one-quarter million units per year.

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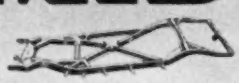
MIDLAND

POWER BRAKE EQUIPMENT


AUTOMOBILE AND TRUCK FRAMES

BUS DOOR CONTROLS

250 Service Organizations To Serve You Wherever You Are

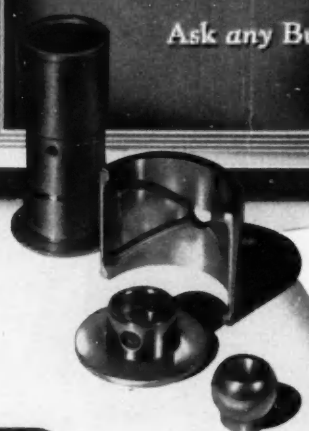
AROUND THE CLOCK AROUND THE WORLD

Among other obligations...

When an order is accepted the obligation to supply the commodity as stated in the contract is routine. But every purchaser knows that there are many other and additional services that the seller can render which serve the convenience and interests of the customers.

Along with every order accepted by the Bunting organization is also accepted the obligation to cooperate with the customer as well as to deliver the items as specified.

Ask *any* Bunting customer.



The sleeve bearing is not complex in structure; it conforms readily to design requirements; it is easily installed. Cast Bearing Bronze is the most adaptable of all sleeve bearing materials; it possesses excellent anti-friction properties. With proper film lubrication, its coefficient of friction is as low as can be obtained with any other bearing type. A successful Bunting Bronze bearing installation is readily attainable. We ask the opportunity to work with you, and to quote on your requirements.

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BRONZE BEARINGS • PRECISION BRONZE BARS • BUSHINGS

THE BUNTING BRASS & BRONZE COMPANY • TOLEDO 1, OHIO • BRANCHES IN PRINCIPAL CITIES

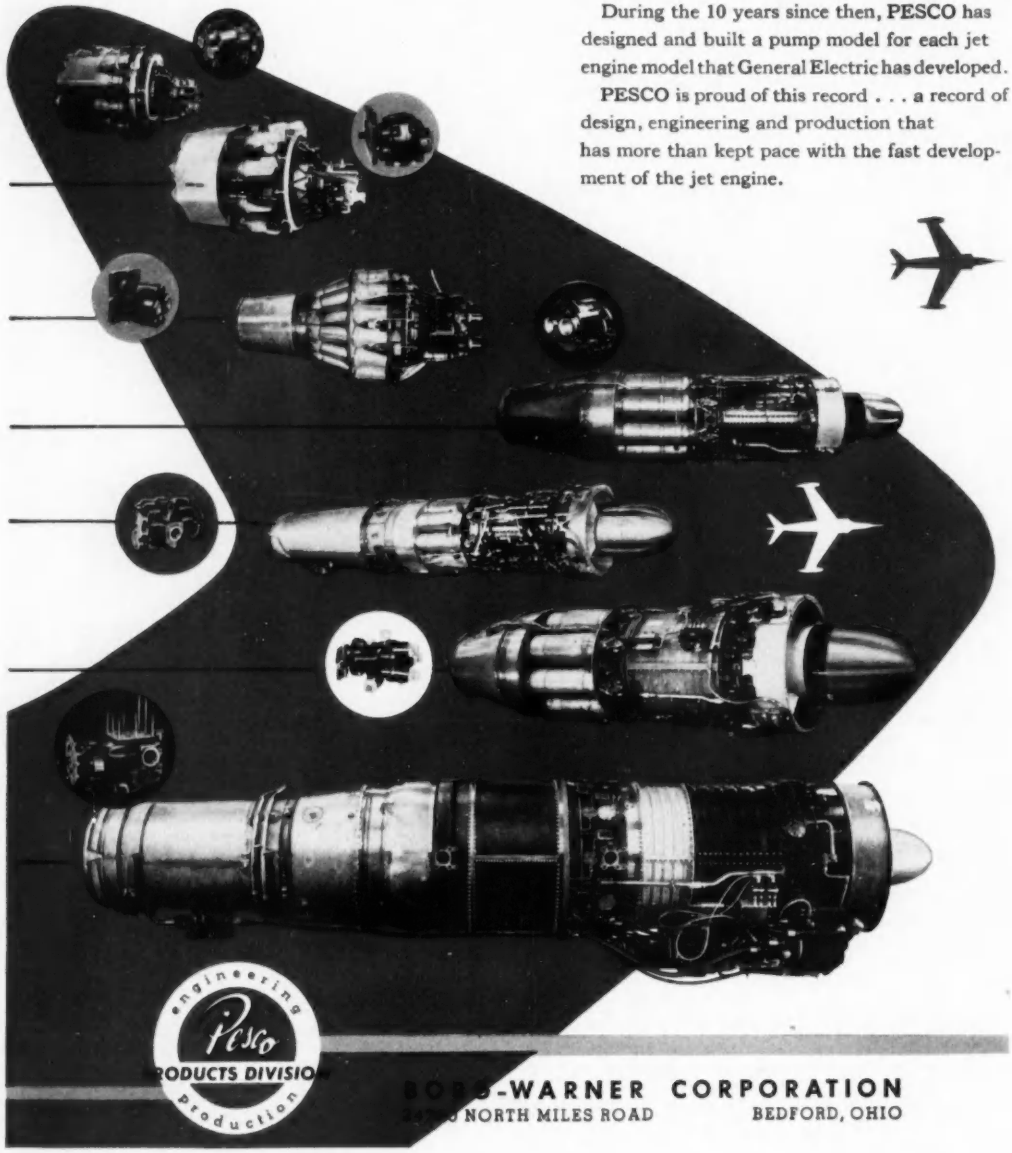
It's been a fast 10 years for PESCO too!

. . . keeping up with G. E. Jet development

When General Electric completed America's first aircraft jet engine in 1942, and jet-powered flight became a reality, a PESCO fuel pump made certain that it was fed all the fuel it needed.

During the 10 years since then, PESCO has designed and built a pump model for each jet engine model that General Electric has developed.

PESCO is proud of this record . . . a record of design, engineering and production that has more than kept pace with the fast development of the jet engine.



engineering Pesco production
PRODUCTS DIVISION

BORG-WARNER CORPORATION
NORTH MILES ROAD BEDFORD, OHIO

HYDRAULICS FOR MOBILE EQUIPMENT

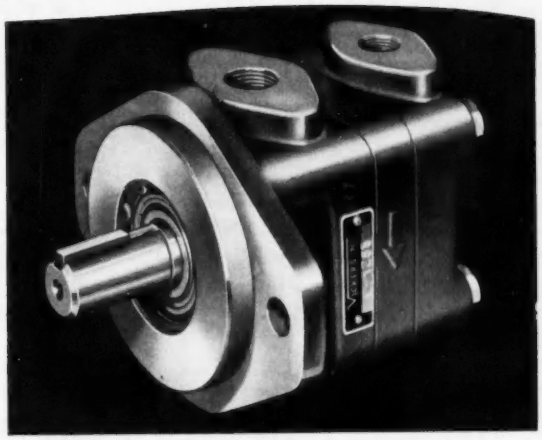
Mobile Equipment News

IMPROVES PERFORMANCE • CUTS COSTS

VOL. 1 — VICKERS INCORPORATED, DETROIT, MICHIGAN — NO. 1

NEW VICKERS SERIES V-100 PUMPS ADDED TO MOBILE EQUIPMENT LINE

Compact, efficient, rugged . . . this new and smaller addition rounds out the Vickers line of vane type pumps designed especially for mobile equipment. These pumps have established a reputation for doing a better job and lasting longer . . . at lower overall cost.



HYDRAULIC BALANCE MEANS LONGER PUMP LIFE

The two internal outlet ports are diametrically opposite each other. The same is true of the inlet ports. Thus equal and opposite thrust loads eliminate bearing loads due to pressure. Lighter bearing loads mean much longer bearing and pump life.

AUTOMATIC WEAR COMPENSATION MAINTAINS TOP PERFORMANCE THROUGHOUT PUMP LIFE

Radial compensation for wear is in the vanes. The vanes slide freely in the slots and are moved out into contact with the cam ring by centrifugal force . . . then held there by hydraulic pressure as it builds up. As normal wear occurs, the vanes just move further out in the slots to compensate. (Wear is minimized because all parts are lubricated by the oil under pressure.)

Axial compensation is by means of a pressure plate held to correct running clearance by pressure from the system. It automatically moves in to compensate as wear occurs.

Automatic compensation eliminates need for "run in" . . . efficiency is maximum the first time the pump is started. It also assures maximum delivery over a very long life, with none of the gradual falling off encountered where there is no wear compensation.

V-100 PUMPS AVAILABLE IN 3 CAPACITIES

The Series V-100 Pump is available in three capacities: 1.5, 2.5, and 3.5 gpm at 1200 RPM and 0 outlet pressure. This choice of three capacities with same exterior dimensions facilitates matching pump to the job.

Ask for Installation Drawing No. 152060.

GREATER MOUNTING ADAPTABILITY

Series V-100 Pumps are available in two mounting styles . . . flange (magneto type) and foot mounting. The pressure connection can be placed parallel, opposite to or at a right angle in either direction to the inlet by simply unbolting and rotating the pump head. Shaft drive is in either direction depending only on internal assembly.

NO-LOAD STARTING

At rest and normal starting speeds, the sliding vanes are retracted; only after engine fires do vanes expand and pumping begins.

OTHER VICKERS BALANCED VANE PUMPS FOR MOBILE EQUIPMENT

Series V-300 pump made in 4 delivery ratings —12 to 24 gpm.
Series V-200 pump made in 4 delivery ratings—2 to 11 gpm.
Series V-400 pump made in 2 delivery ratings— 28 and 38 gpm.
Series V-500 pump in 2 delivery ratings—50 and 65 gpm.

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1440 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • NEW YORK (Metropolitan) • PHILADELPHIA (Metropolitan) • PITTSBURGH • ROCHESTER • ROCKFORD • ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

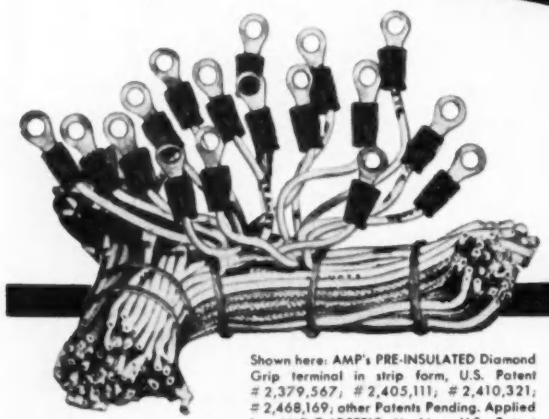
UNIFORMITY!

Plus lowest installed cost of any *insulated* wire termination!

Combination of AMP Automatic Wire Terminators and AMP PRE-INSULATED* strip terminals gives an all time high in precision and uniformity at lowest possible unit cost. All the advantages of solderless methods plus SPEED. No heat, no solder, no irons or flux, no cold joints; no separate insulation tubing. Yet tests prove AMP terminals superior in all respects: conductivity, tensile strength, resistance to corrosion, vibration and bending, heat, etc. Human error in terminal application is all but eliminated! Connections are free from R.F. Noise; safe for most critical applications.

SEND FOR SPECIAL AUTOMATIC MACHINE CATALOG!

THE ONLY AUTOMATIC WIRE TERMINATOR *PROVEN* BY YEARS OF CONTINUOUS SERVICE! WRITE FOR A DEMONSTRATION IN YOUR PLANT!



Shown here: AMP's PRE-INSULATED Diamond Grip terminal in strip form, U.S. Patent # 2,379,567; # 2,405,111; # 2,410,321; # 2,468,169; other Patents Pending. Applied by AMP-O-LECTRIC Machine, U.S. Patent # 2,396,913; other Patents Pending.

*Trade-Mark
AMP Trade-Mark Reg. U. S. Pat. Off.

NON-INSULATED AMP terminals and connectors can be applied at rates up to 4,000 terminations per hour!

AMP

AIRCRAFT-MARINE PRODUCTS INC.
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Spicer

SPECIALISTS IN SERVICE

Spicer Clutch Quality...

has served the quality truck field since 1911

Spicer and Spicer Brown-Lipe Clutches have been an integral part of the revolution in transportation which the truck has brought to the world. The first Brown-Lipe Clutch for truck service was shipped on March 10, 1911. The transition from that period of the plodding horse, to the swift-moving commercial vehicle of today, has taken but a relatively few years. The vision, genius and untiring efforts of the automotive industry have helped shape this modern miracle. And into it has gone endless thousands of Brown-Lipe Clutches of Spicer quality . . . *Standard of the Industry.*

Spicer

SPECIALISTS IN SERVICE

Spicer
BROWN-LIPE CLUTCH

keeps things moving when the trucking is rough

Spicer Brown-Lipe Clutch service is measured in terms of years, operating under every condition of truck service encountered in the industry. Special features include:

UNIFORM OVERALL PRESSURE. Through 360° of pressure plate.

SIMPLE SCREW THREAD ADJUSTMENT. Permits quick, easy adjustment.

LONGER BEARING LIFE. Completely shielded release bearing.

NON-WARPING PRESSURE PLATE. Made of heat treated alloy.

SMOOTH. Flexibility of levers results in smooth pick-up.

NO CHATTER. Assures longer life.

LOW PEDAL PRESSURE. Remains essentially constant throughout clutch life.

FEWER PARTS. Greater efficiency with less upkeep.

INSULATED SPRINGS. Heat from plate cannot destroy their temper.

ECONOMICAL. Delivered completely engineered—not necessary to design or purchase special transmission front bearing caps, clutch release bearings or housings.

48 YEARS OF Spicer SERVICE

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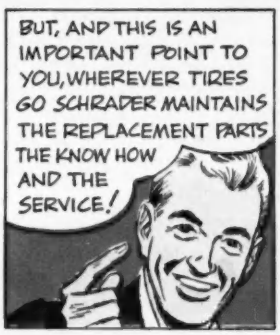
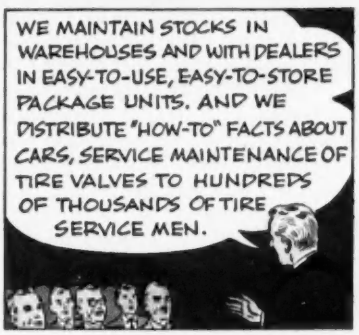
Division of Dana Corporation • **TOLEDO 1, OHIO**

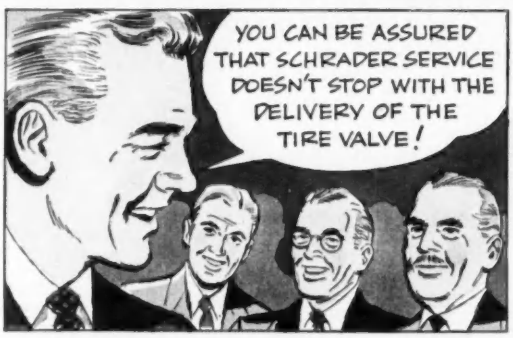
TRANSMISSIONS • UNIVERSAL JOINTS • BROWN-LIPE AND AUBURN CLUTCHES • FORGINGS • PASSENGER CAR AXLES • STAMPINGS • SPICER "BROWN-LIPE" GEAR BOXES • PARISH FRAMES • TORQUE CONVERTERS • POWER TAKE-OFFS • POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES

Schrader Contributions to the Tire Industry

YOUR NEW TIRES WITH NEW SCHRADER STANDARD TIRE VALVES GO ALL OVER THE WORLD YEAR AFTER YEAR. SOME TIRES AND VALVES WILL BE ABUSED AND NEED REPAIRS.


BUT, AND THIS IS AN IMPORTANT POINT TO YOU, WHEREVER TIRES GO SCHRADER MAINTAINS THE REPLACEMENT PARTS THE KNOW HOW AND THE SERVICE!


WE MAINTAIN STOCKS IN WAREHOUSES AND WITH DEALERS IN EASY-TO-USE, EASY-TO-STORE PACKAGE UNITS. AND WE DISTRIBUTE "HOW-TO" FACTS ABOUT CARS, SERVICE MAINTENANCE OF TIRE VALVES TO HUNDREDS OF THOUSANDS OF TIRE SERVICE MEN.



Schrader service backs you right down to your own customer . . . the consumer. Whether he is a fleet operator with 500 trucks or your neighbor with the family car . . . Schrader provides all the information and equipment to dealers everywhere to help your customer get all the miles you built into your tires.

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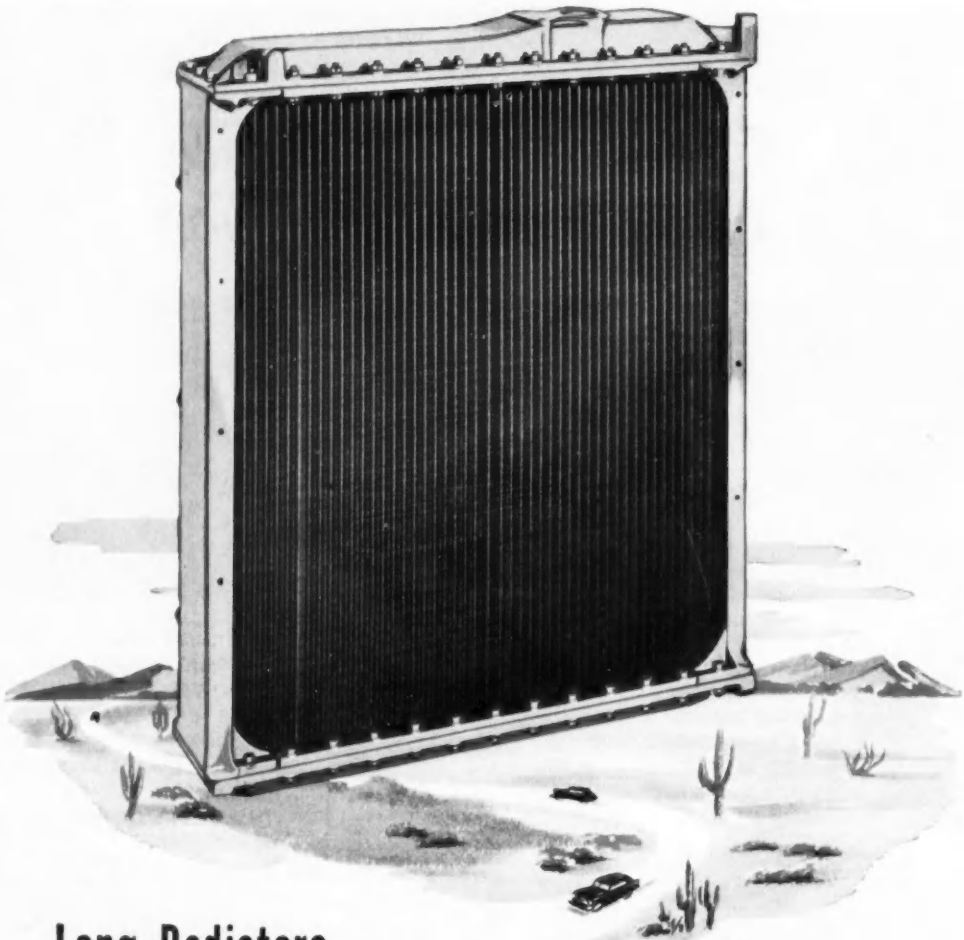
Schrader
REG. U. S. PAT. OFF.

FIRST NAME IN TIRE VALVES
FOR ORIGINAL EQUIPMENT AND REPLACEMENT



Long Radiators *for Balanced Cooling*

With nearly fifty years of specialization in radiator manufacturing, we offer the automotive manufacturer important advantages:

The widest possible range of sizes and capacities.

Engineering design and production skill that only long years of specialization can bring.

The background of countless applications of our concept of *balanced engine cooling.*

LONG MANUFACTURING DIVISION
Borg-Warner Corporation
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B-W

LONG

CLUTCHES • RADIATORS • TORQUE CONVERTERS
OIL COOLERS

EQUIPMENT UNITS THAT BESPEAK QUALITY

AC's PROVING GROUNDS

America's busy highways and quiet country lanes are the proving grounds for AC's equipment units. There, under every condition of road or load, the finished products of over 300 manufacturers are proving 22 kinds of AC equipment.

Every year, new customers are added to AC's impressive list. That's convincing evidence of AC's ability to pass the greatest test of all — the constant grind of year-round service.

Is your problem performance? Serviceability? Long life? AC engineers will work with yours to apply any of their 22 products to your specific needs.

• ADAPTERS (Drive) • AIR CLEANERS • AIR CLEANERS AND SILENCERS (Combination) • AMMETERS • BREATHERS (Crankcase) • CAPS (Radiator Pressure) • FLEXIBLE SHAFT ASSEMBLIES • FUEL PUMPS • FUEL AND VACUUM PUMPS (Combination) • FUEL FILTERS & STRAINERS • GASOLINE STRAINERS • GAUGES—AIR (Pressure) • GAUGES—GASOLINE • GAUGES—OIL (Pressure) • GAUGES—TEMPERATURE (Water, Oil) • OIL FILTERS (Lube) • PANELS (Instrument) • SPARK PLUGS • SPEEDOMETERS • TACHOMETERS • TERMINALS (Ignition Wire) • VALVES (Crankcase Ventilation)

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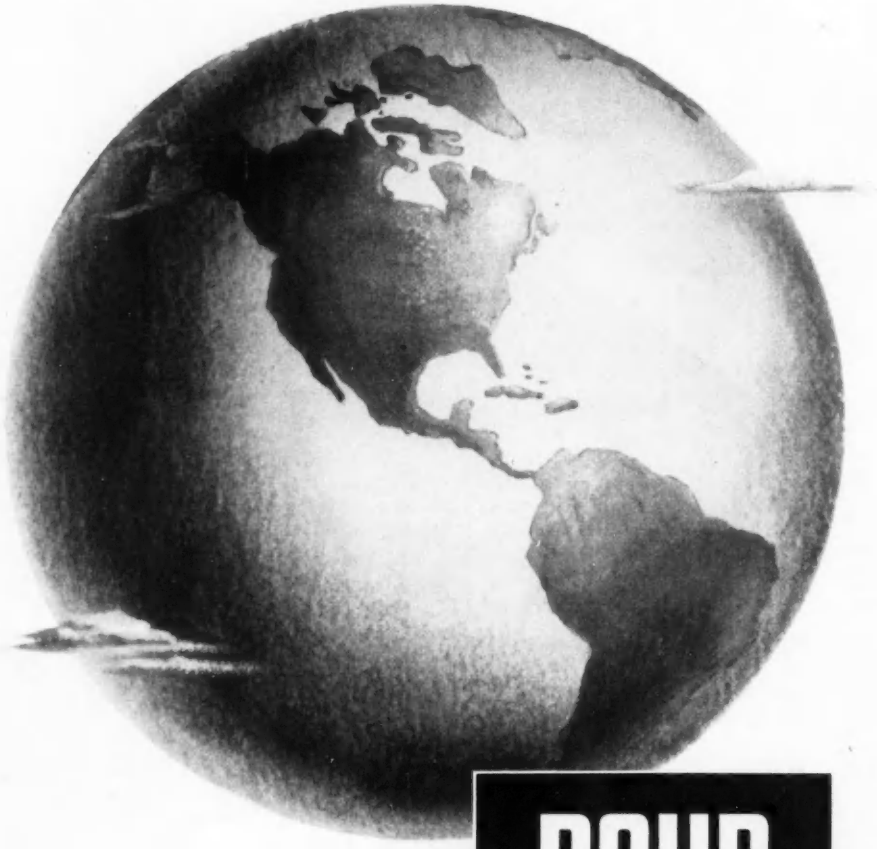
AC SPARK PLUG DIVISION GM GENERAL MOTORS CORPORATION

WORLD'S LARGEST PRODUCER OF
READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES



ROHR
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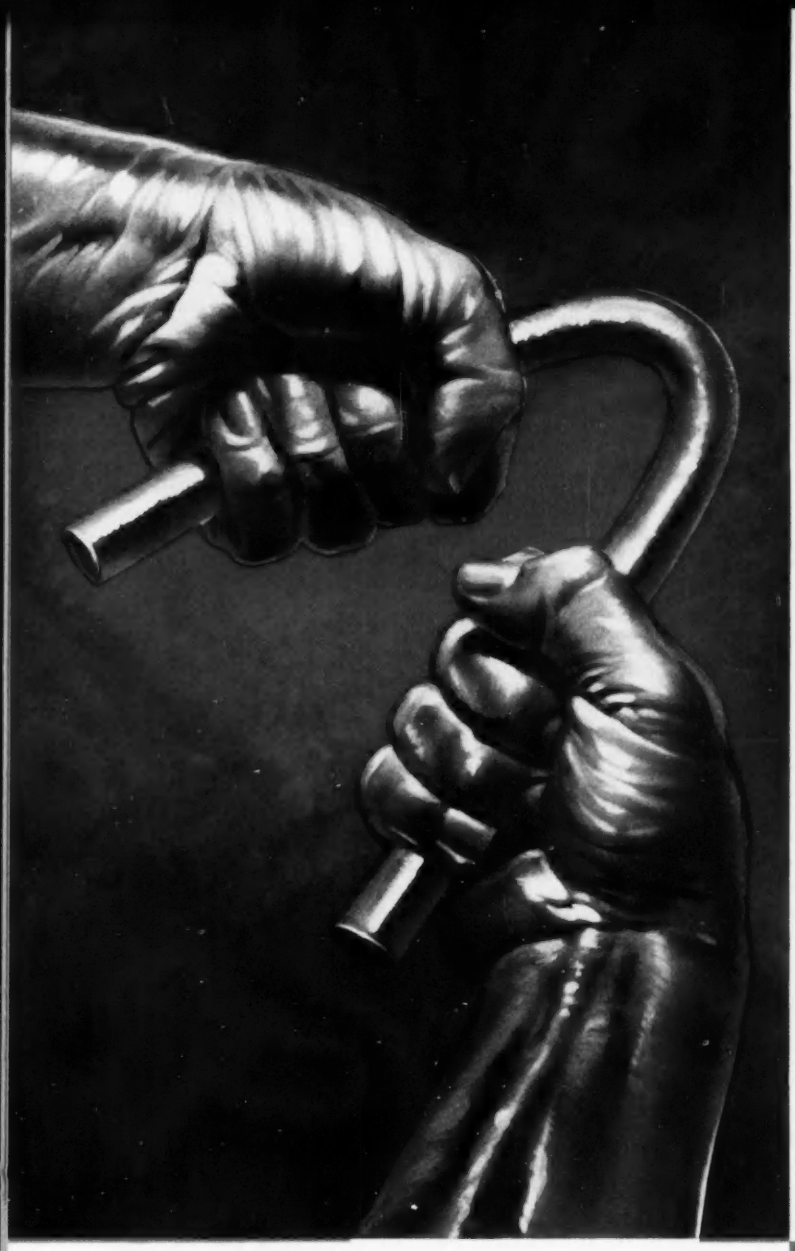
CHULA VISTA AND RIVERSIDE
CALIFORNIA



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are needed to shape America's future.

Take an active interest in politics today. It's our best protection against Socialistic regimentation tomorrow.

Know how your candidates stand.

BOHN

BOHN ALUMINUM & BRASS CORPORATION
GENERAL OFFICES: LAFAYETTE BLDG. • DETROIT 26, MICHIGAN

CASTINGS • FORGINGS • PISTONS • BEARINGS • EXTRUSIONS
INGOTS • REFRIGERATION PRODUCTS • AIRCRAFT PARTS
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"American Forum of the Air" . . . . . Every Sunday on NBC Television
Consult Your Newspaper for Time and Station

Great names in the Automotive Industry

EDWIN ROSS THOMAS

Edwin Ross Thomas was manufacturer of the famous Thomas Flyer, which was said to be the most powerful car of its day. It was the first to have a side door entrance, first with a 6-cylinder motor and first to offer a limousine-type body.

Over the years, the Thomas Flyer gained considerable renown as a racer—winning 89 times in a single year and defeating Europe's best in the historic New York-to-Paris race westward via Siberia in 1907-1908.

In 1907 when Roy Chapin and Howard Coffin entered the automobile field after having worked for R. E. Olds, Thomas backed them in organizing the Thomas-Detroit Motor Company which later became Chalmers-Detroit when Hugh Chalmers joined the group. In 1911, Thomas' automobile interests were merged into the United States Motor Company and he retired from the industry.

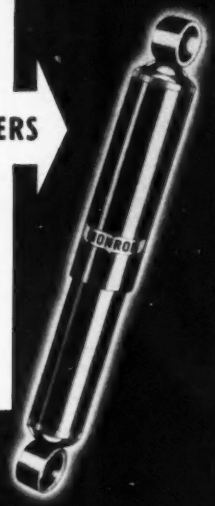
(One in a series of sketches about great automotive industry pioneers.)

MONROE—THE GREAT NAME IN SHOCK ABSORBERS

Together with better highways, improved ride control devices have greatly smoothed travel for America's autos, trucks and buses during the last half century. Monroe has pioneered in developing the best ride control products —shock absorbers, sway bars, struts and molded rubber parts. Today, Monroe ride control products are top choice among America's automotive engineers.

MONROE®

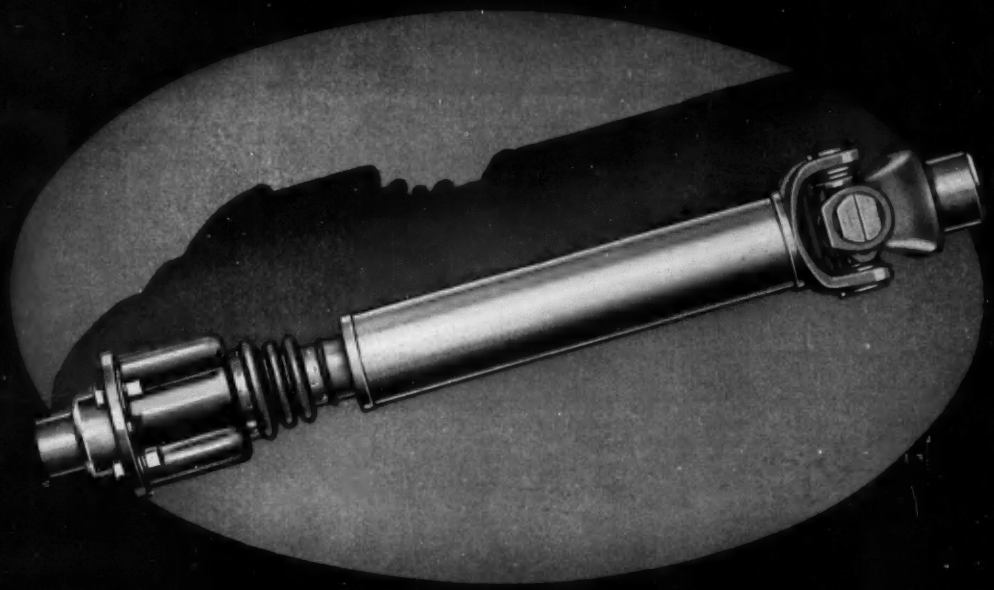
Monroe Shock Absorbers are standard equipment on more makes of new cars than any other brand of shock absorber.



MONROE AUTO EQUIPMENT CO.

Monroe, Mich.— World's Largest Maker of Ride Control Products

Eliminate Spline Friction



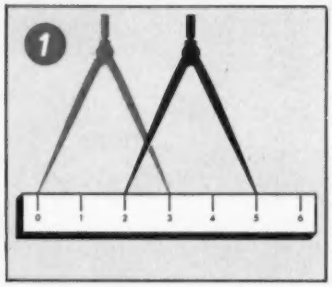
with "DETROIT'S" Exclusive Universal Joint Combinations

A smoother car ride and longer drive train life are assured by "DETROIT'S" exclusive universal joint combinations. This is accomplished because slip motion, angular motion and length changes are permitted with no spline friction. Thus the thrust load on transmission and axle bearings is reduced to an absolute minimum.

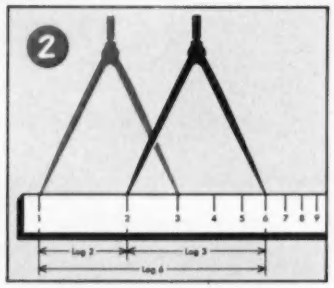
Detroit UNIVERSAL JOINTS

UNIVERSAL PRODUCTS COMPANY, Inc., Dearborn, Michigan

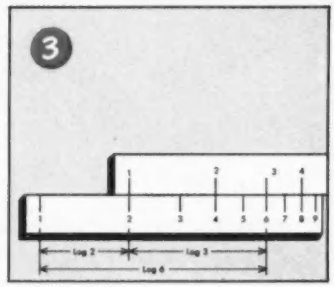
Why a Slide Rule Adds



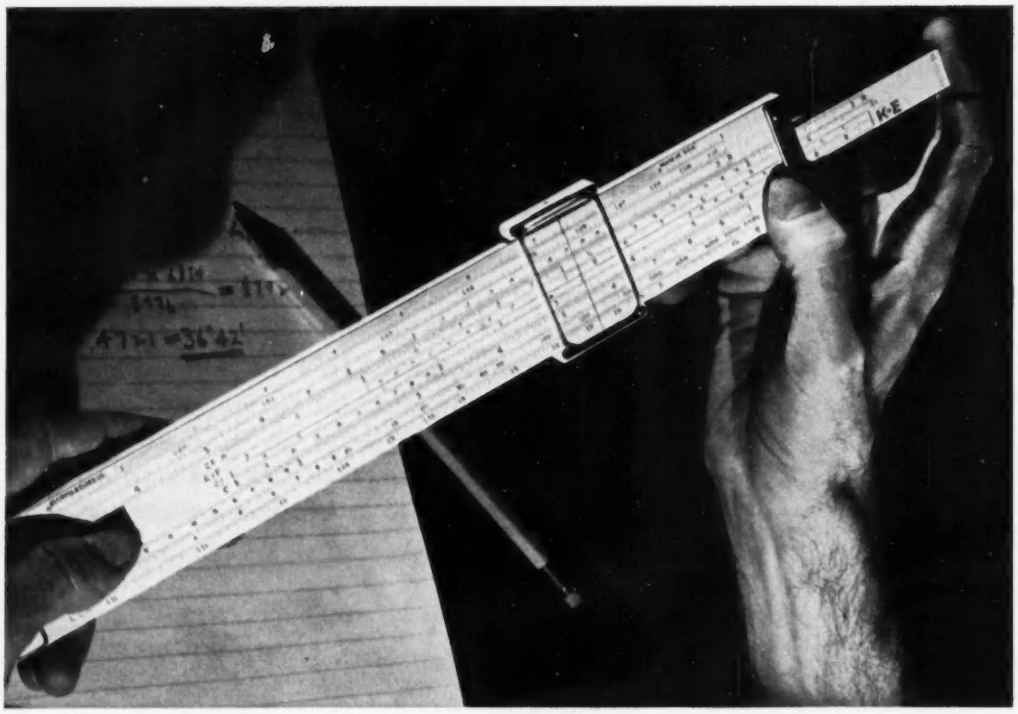
In a mechanical sense, the slide rule merely adds and subtracts quantities. How these simple operations can be performed mechanically may be seen from the illustration above, which shows the addition of 2 and 3 by means of a pair of dividers applied to an ordinary 6-inch rule. Even many electronic calculators work basically on this principle.



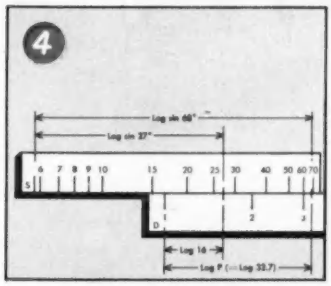
With a different system of calibrations on the scale, if appropriate meanings are assigned to them, more difficult problems may be solved in the same way. An example of this is seen above where a pair of dividers is shown adding 2 and 3 on a logarithmic scale and obtaining the answer 6. Advantage is taken of the fact that the multiplication of numbers may be accomplished by the addition of their logarithms.



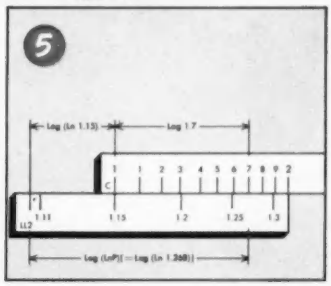
A handier method, which begins to approach the usefulness of a slide rule, is to place two similar logarithmic scales together. Seen above is the simple setting in which 2 is shown being multiplied by 3. Observing the illustration it can be seen that the same setting also multiplies 2 by 2 and 4. Without changing the setting, the device shows the corresponding operations in division.



to Multiply



Problems in plane trigonometry require only appropriate logarithmic scales, calibrated to read in degrees so that operations can be performed on the functions of angles. Two scales of this kind are generally used: one for the sines of angles and the other for tangents. Above is seen a setting for finding $P = \frac{16 \text{ Sin } 68°}{\text{Sin } 27°}$.



Problems of greater complexity, involving higher powers and roots of numbers, including fractional and negative powers and roots, can also be made as easy as 2 + 3 by means of appropriate logarithmic scales. Known as log log scales, they are calibrated to read in logarithms of logarithms. Above is seen a setting for finding $P = 1.15^{1.7}$.

The slide rule has been called the symbol of the engineer. The symbol that distinguishes the slide rule itself for leadership in design and workmanship is the K&E trade mark or the name KEUFFEL & ESSER CO.

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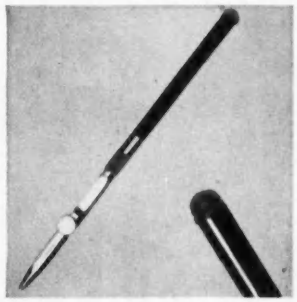
The Right Angle



If you'd like l-o-n-g mileage without re-sharpening, get a PARAGON* RED TIP ruling pen. They are tipped with tungsten carbide alloy butt-welded to stainless steel blades. Ideal for use on aluminum, glass cloth and other abrasive surfaces as well as on regular paper or cloth. Identify it by the red tip at the end of the handle.

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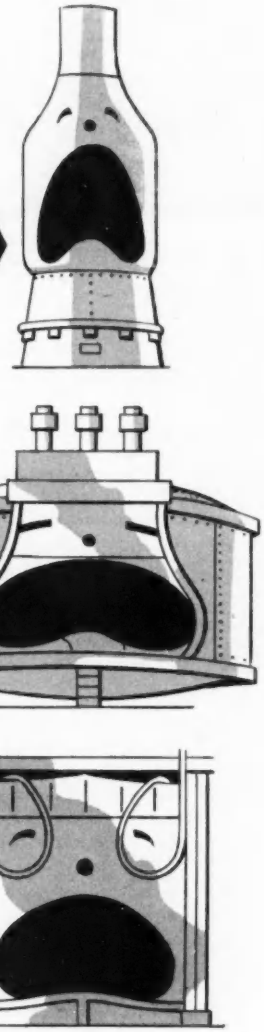

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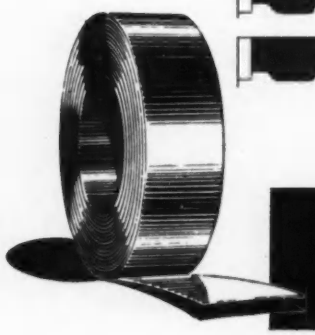

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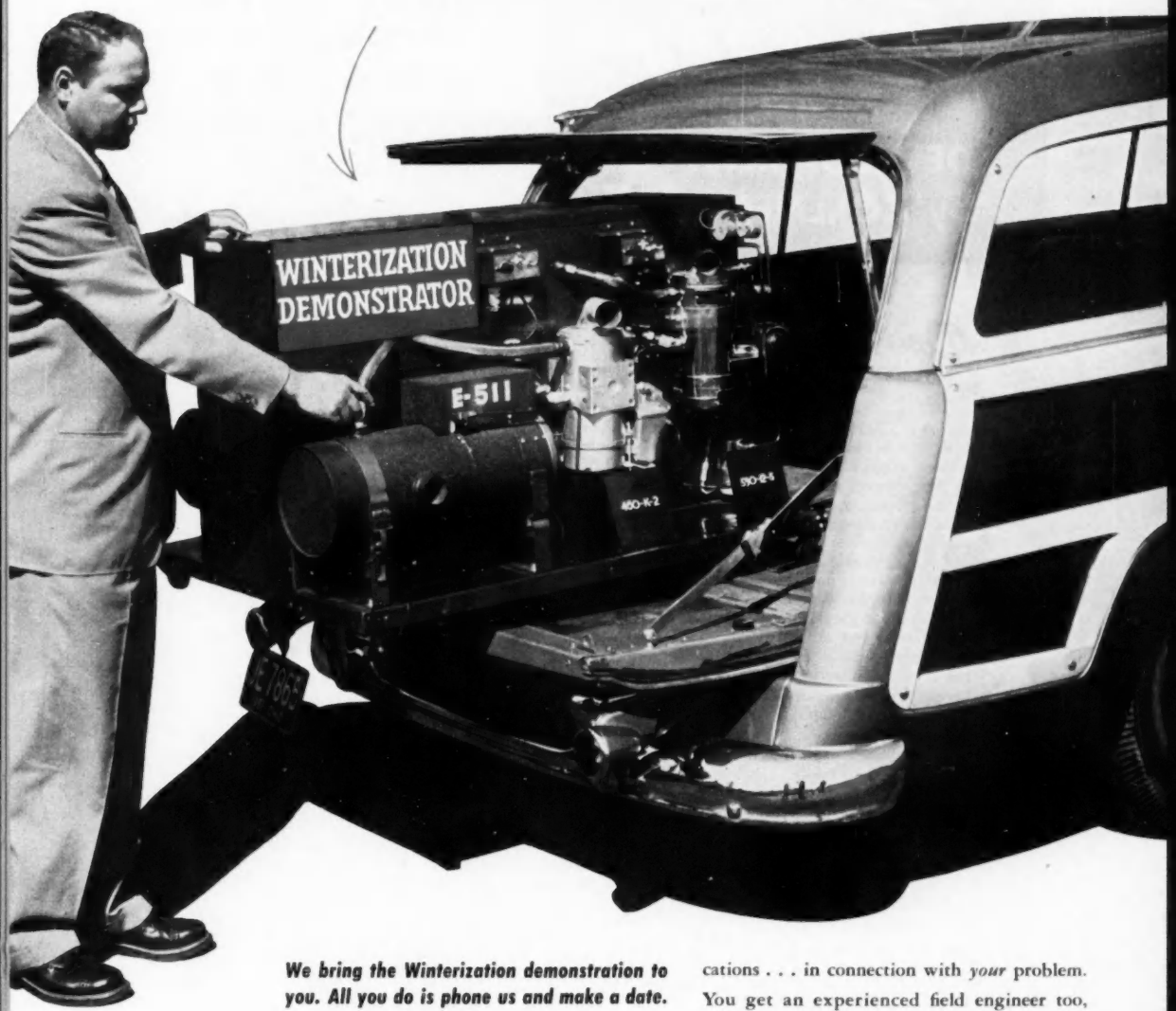

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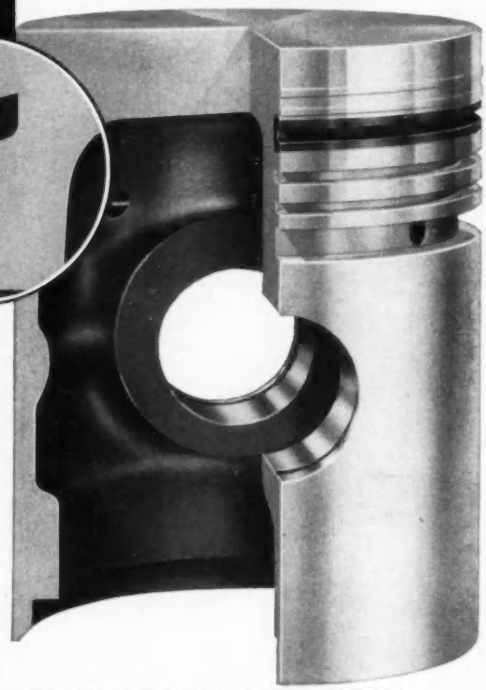
PISTONS



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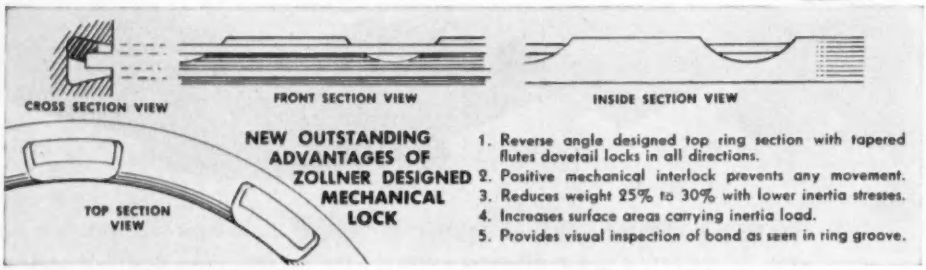

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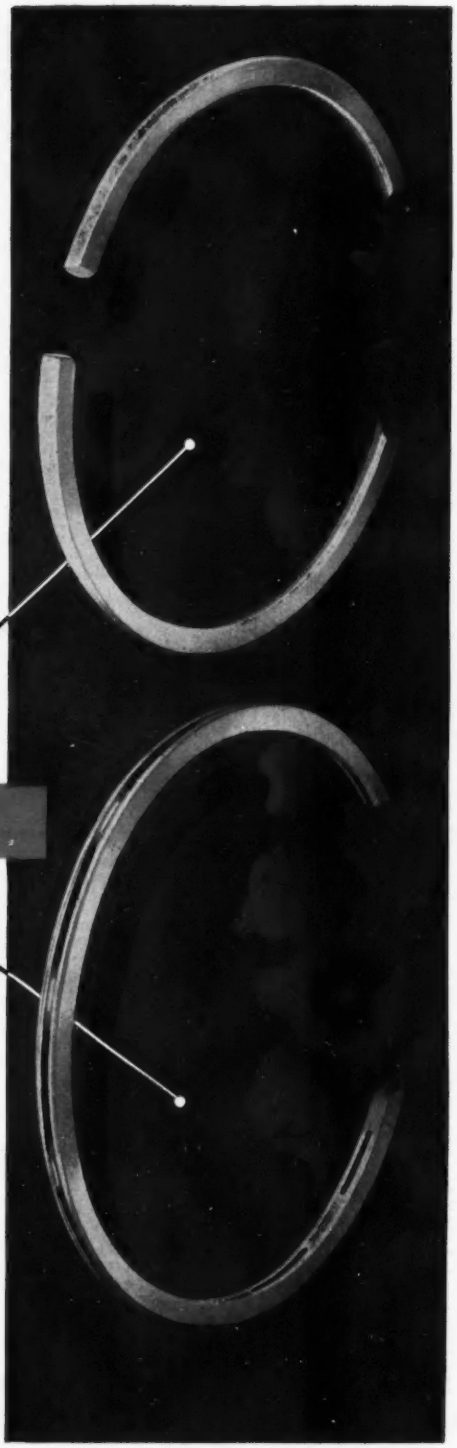

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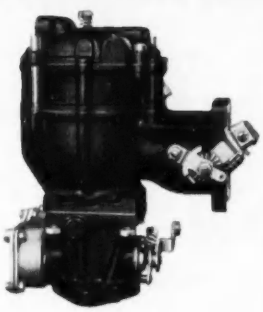

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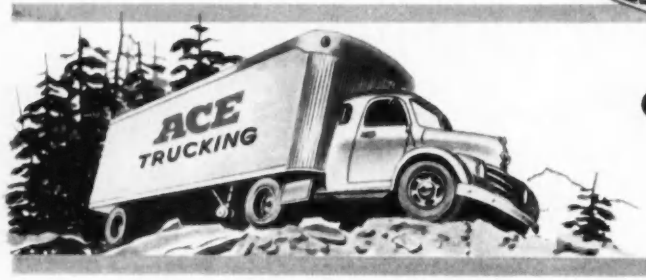

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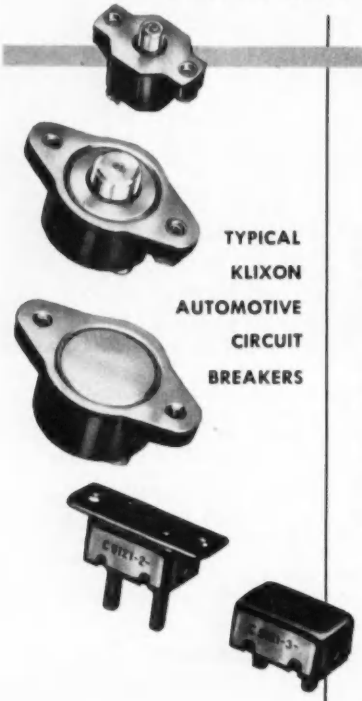

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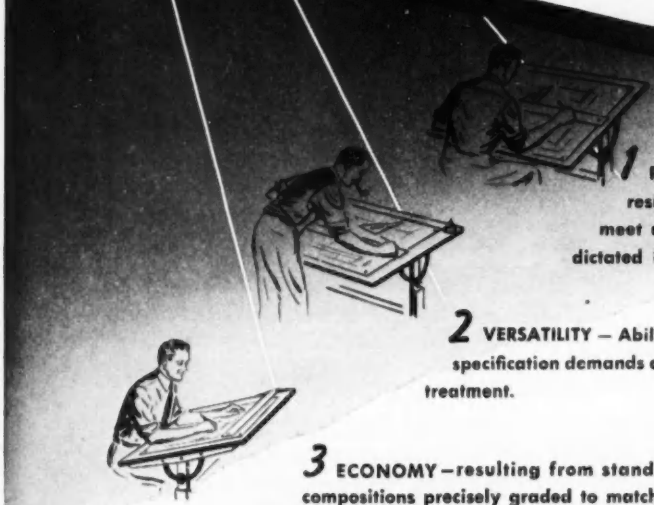

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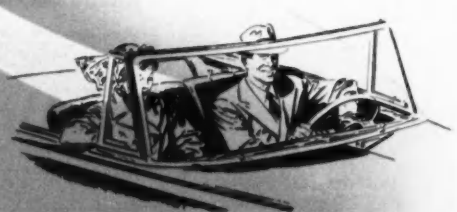

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tractors equipped with Wagner Air Brake Systems

are nearing the 300,000 mile mark and are still performing

users are our biggest boosters

MID-STATES
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June 19, 1951

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MID-STATES FREIGHT LINES, INC.

John W. Ferguson
Manager - Highway Operations

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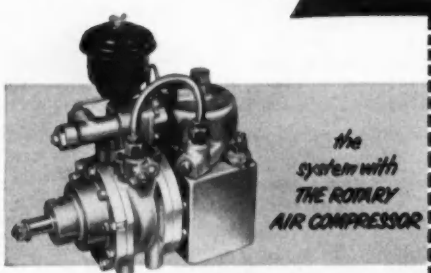

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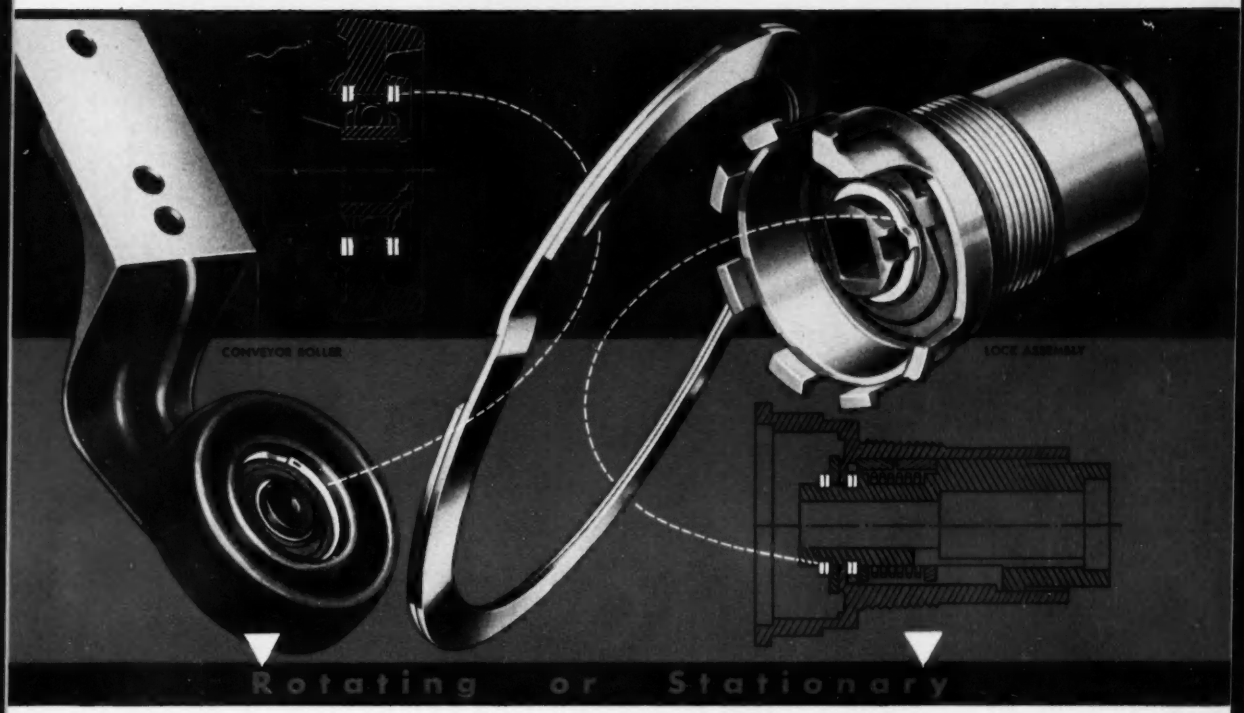

assemblies retained with Spirolox look neater, last longer, use fewer parts, are easier to take apart and put together

Wherever parts rotate, wherever parts are to be secured on shafts or in housings, wherever moving parts must *hold* together —Spirolox Retaining Rings do the job better! Even on rotating assemblies, as shown in the conveyor roller application at left above, Spirolox attains neat, compact, simplified design. The stationary application of a lock assembly (right above) illustrates how Spirolox can be applied in those hard-to-reach places where the retaining ring must operate in a very confined space.

Exclusive Spirolox Design makes possible a variety of applications that is almost limitless. Secret of this design is the patented Spirolox *two-turn construction*, which ELIMINATES THE GAP and makes possible a UNIQUE LOCKING CHARACTERISTIC. A step or offset, formed in the ring so that the two turns are parallel, *bridges the gap* found in conventional retaining rings. Result: better conformability, even in the most restricted places. The effective locking property of Spirolox is created by a "friction lock", formed under thrust between the two turns. Result: greater holding power to make the ring STAY PUT in its groove.

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Spirolox RETAINING RINGS

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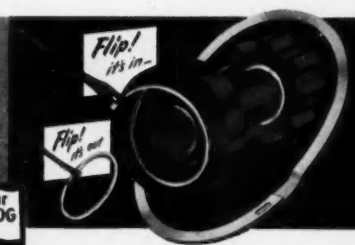

see our CATALOG in SWEET'S FILE

gapless • concentric • requires no special tools • easy-in, easy-out • re-usable • stays put

Where lights must be kept burning, specify SILASTIC* lead wire

In the chemical industry where lights, essential to the safety of working men, burn 24 hours a day; along the runways of airports; in railway yards and control towers; along the docks and in beacon lights off-shore; Silastic-covered lead wire can assure continuous, trouble-free operation, and pay for itself in reduced maintenance and replacement costs alone. ¶ In the huge Midland plant of The Dow Chemical Company, for example, all lighting circuits are carried in conduit that doubles as supports and hangers for more than 50,000 lighting fixtures. Many of these are vapor-proof or explosion-proof fixtures where heat is a more serious problem. Over half of these fixtures burn constantly. Most of them are exposed to outdoor weathering. ¶ Under those conditions, maintenance and replacement were such a costly problem that engineers in the Electrical Department tried, and now specify, lead wire insulated with Silastic. This Dow Corning silicone rubber is the only kind of rubbery insulating material that retains good dielectric properties and will not crack or become brittle after long and continuous exposure to outdoor weathering at temperatures from —70° to +350° F. ¶ Silastic is also used as a gasketing and sealing material in hundreds of aircraft and automotive applications, at temperatures ranging from —100° to more than +500° F. It is unique among electrical insulating materials for Class B and Class H lead wire, for ignition and Navy control cable, and for transformers and field coils in traction motors.

Put Silastic to work for you; mail this coupon to:

Dow Corning Corporation, Dept. V-20
Midland, Mich.
Please send me:

- ☐ Silastic Facts 10a with new data on properties and applications of all Silastic stocks and pastes.
- ☐ "What's A Silicone?", your new 32-page booklet on silicone products and applications.

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*T.M. Reg. U.S. Pat. Off.

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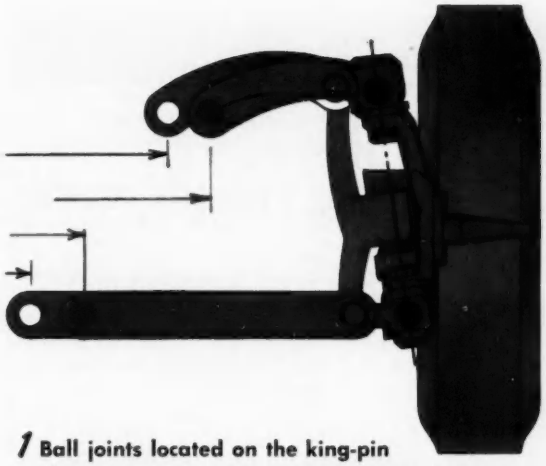


1 **Ball joints located on the king-pin line move inner pivots outward, creating extra inches under the hood for wider engine design.**

Ball Joint Suspension

1 **GIVES MORE SPACE FOR WIDER ENGINES**

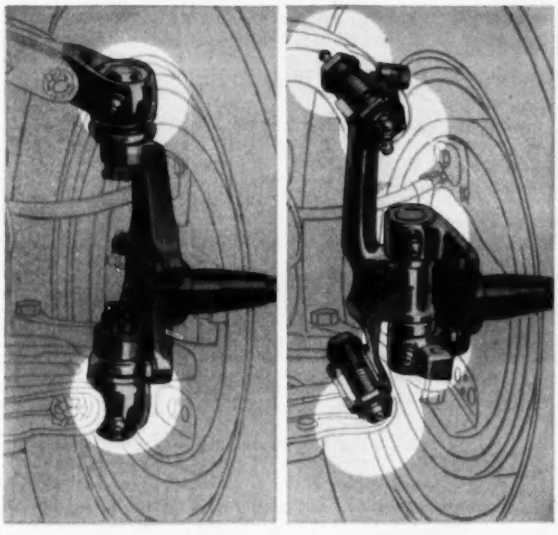
2 **REDUCES LUBRICATION SERVICE 75 PER CENT**

3 **MAKES FRONT WHEEL SUSPENSION INSTALLATION EASIER AND FASTER**

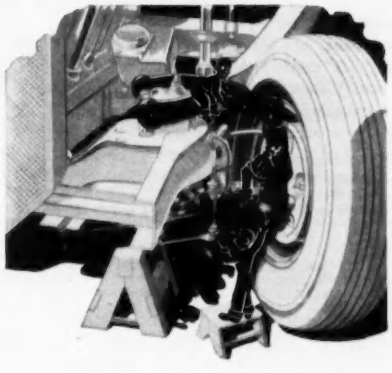
ONE GLANCE at the illustrations and you see how valuable inches are saved under the hood! Quick comparison points out the number of lubrication services eliminated. But these are only small points in the over-all story.

Thompson's Ball Joint Suspension also eliminates front suspension bind. It improves steering; makes handling easier; and prolongs service life. Through weight savings, parts reduction and compact design, Ball Joint Suspension speeds assembly. And in servicing, the equivalent of a complete rebushing job can be done in half an hour because removal of front wheels and bushings, bleeding the braking system and normal realignment are unnecessary.

Let Thompson's "ENGINEERED STEERING" experts help you solve your steering problems. Inquiries from all automotive makers are welcome at Thompson's Detroit Division. Call us at WA 1-5010.



2 **Lubrication points are reduced from 12 to 4 by eliminating upper and lower standard threaded bearings, knuckle support, king-pin and its bushings.**



3 **Only three simple operations are required to assemble or remove the compact service package from the suspension.**

Thompson Products, Inc.

DETROIT DIVISION

7881 CONANT AVENUE • DETROIT, MICHIGAN

NATIONAL OIL SEAL LOGBOOK

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California office

Sealing different types of lubricant in full-floating truck axle assembly

Heavy-duty vehicles such as trucks, tractors and off-highway equipment frequently require widely different lubricants for adjoining sections of an assembly. In many cases, oil seals are necessary to prevent intermixing of lubricants as well as preventing entry of dust and dirt to bearing or gear areas.

In the typical full-floating truck axle (Figure 1), special oil to withstand extreme gear loading is used in the differential, and conventional bearing grease at the wheel position. These two lubricants must be retained within assigned areas; they must be kept separate; dust, dirt and mud must be excluded. In the assembly illustrated, this is accomplished through the use of two National Oil Seals of standard design.

A modified National 350,000 seal is installed outboard of the outer roller bearing (Figure 1, "A") to retain gear oil within the differential and axle housing. This is a National Syntech* seal with a precision-molded, precision-trimmed synthetic rubber sealing member, accurately spring tensioned. Accurate concentric positioning of the seal is assured by a special shoulder fitting into the wheel hub bore. Sealing is further improved by riding the sealing lip on a replaceable sleeve press-fitted onto the axle housing.

At the inner bearing position (Figure 1, "B"), a modified National 50,000 series leather seal is employed. This seal retains grease around the bearing and excludes minor amounts of foreign matter. Leather is preferred for this assignment since the seal may frequently run "dry" due to lack of lubrication. National leather seals with impregnated "Nationalized" sealing members are ideal for such semi-starved conditions, as well as other heavy-duty applications of a semi-pressure or semi-dirt nature.

Both seals in this assembly are standard-design National seals modified to meet space limitations of the application. Where sealing problems are critical, special designs are often required to meet pressure, speed, lubricant or temperature conditions. In many applications, however, manufacturers save appreciably on time and tooling costs by utilizing standard-design National Oil Seals. National has tools for over 1,000 such designs—can produce and ship promptly to your order. For complete information, call the National Oil Seal engineer in your city, or write direct.

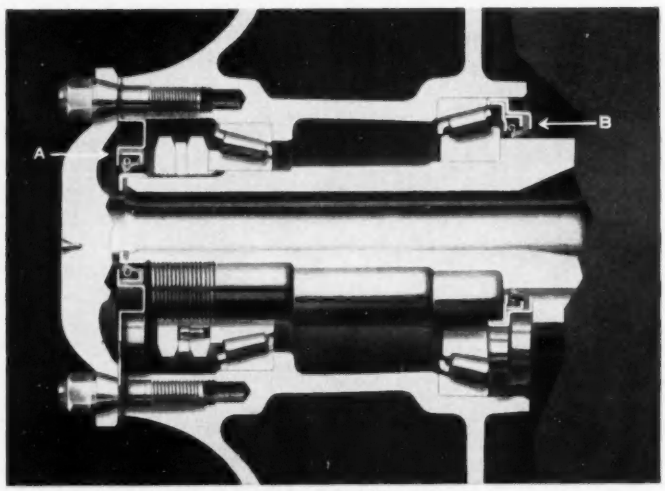


Figure 1. Wheel assembly, full-floating truck axle

Modified National 350,000 Syntech* Seal

Modified National 50,000 Leather Seal

"Let Your Decision be Based on Precision"

NATIONAL OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

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AN 3100A WALL MOUNTING RECEPTACLE **AN 3106A STRAIGHT PLUG**

Snap-in sleeve on Monowatt Wall Mounting Receptacles and Straight Plugs allows easy access to insert for soldering and inspection. Sleeve snaps in and cannot work loose, yet can be released quickly with a small screwdriver for removal of insert. With this new type sleeve and Monowatt's one-piece solid housing it is possible to use a solid shell connector in applications which would otherwise call for a split shell. Extra weight and possible loosening of threaded parts under vibration is eliminated.

AN 3108B ANGLE 90° PLUG

Slide-off cover on Monowatt Angle 90° Plug is easily removed for soldering or inspection. Insert does not have to be removed. Set screws are drilled for safety wiring.

Is it a question of delivery? Meeting specifications? Reducing assembly and inspection costs? The Monowatt Department of General Electric Company can help you solve such problems.

Monowatt is now supplying AN connectors for Lockheed, Chance Vought, Minneapolis-Honeywell, and many others. With complete, modern facilities for mass-production, we can offer, on a fast-delivery basis, connectors conforming to latest Government specifications at competitive prices.

If you require AN connectors—or any of the wiring components shown below—you will be interested in what Monowatt can do for you.

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And you can count on MONOWATT for all types of electrical components — made to your specifications

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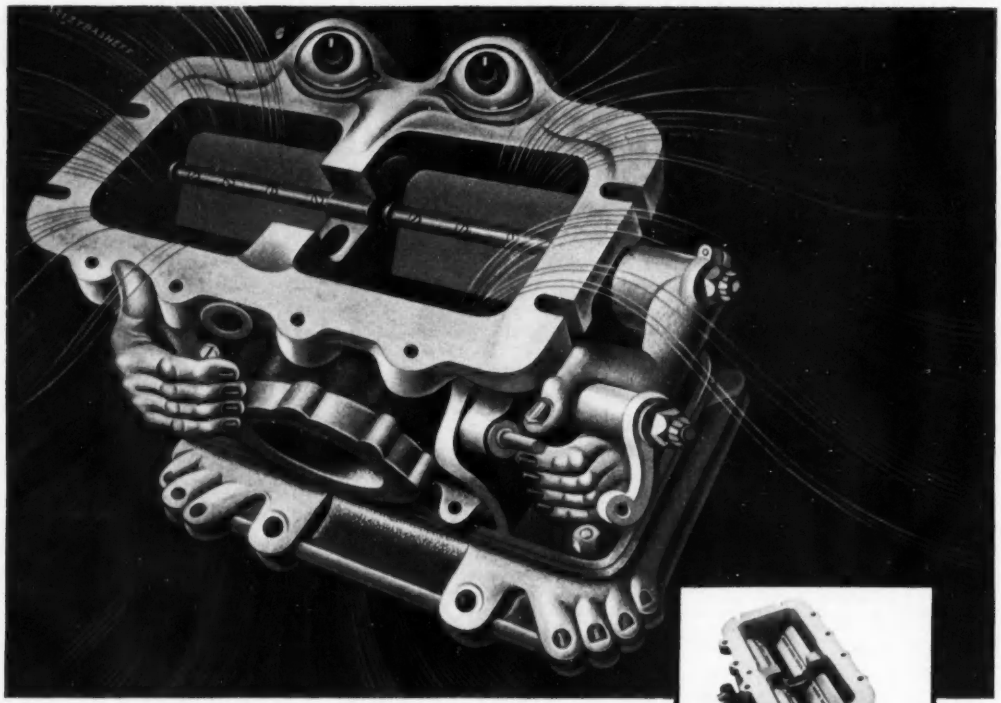

Watch a plane's "lung" take a deep breath

An aircraft engine gulps *15 times* more air than fuel. To control this air flow—adjusting perfectly to frequent changes in speed and altitude—requires a precision-machined "lung" that never leaks, never coughs. Producing a part so precise typifies Lycoming resourcefulness and skill, long famous in the aircraft field—increasingly in demand throughout *all* American industry.

Whether you require precision machining, high-volume production, product development—or air-cooled power for aircraft or ground applications—Lycoming offers extensive facilities and experience.

Whatever your problem—look to Lycoming!

To inhale 30,000 pounds of air every hour, a plane needs good lungs. For a fuel-injection body that "breathes steady," **one of America's leading aviation corporations calls on Lycoming precision production.**

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DESIGN TELLS THE STORY

Gunite truck and trailer wheels are skillfully engineered to stand the gaff of "peak-load" operation. Tubular spoke design provides maximum strength through accurate weight distribution. Six low-torque floating rim bolts assure easy-servicing and true alignment with rim clamp. Made of fine-quality cast steel, Gunite tubular-spoke wheels are rugged . . . yet, save vital pounds . . . assure minimum unsprung weight . . . cut costs per every mile of operation. Best of all, you can specify Gunite lightweight cast-steel wheels at no premium in price.

GUNITE

GUNITE FOUNDRIES CORPORATION, Rockford, Illinois

MOBILIFT ENGINEERING PROVIDES FINGER-TIP CONTROL

A new series of 3,000- and 3,500-lb. capacity, stand-up fork lift trucks, manufactured by Mobilift Corporation, Portland, Oregon, feature Lev-R-Matic Drive, finger-tip control of forward-back movement, elevating and tilting. Careful design and engineering provide these trucks with other popular features, too—abundant, reliable power, plenty of forward visibility for the operator, automatic "Dead Man" safety brake, cool operation, exceptional maneuverability.

SKF ENGINEERING PROVIDES TROUBLE-FREE BEARING PERFORMANCE

To keep maintenance low and efficiency high, Mobilift Series H Fork Lift Trucks use a total of 44 SKF single and double-row deep groove ball bearings. Mobilift Corporation, like many other manufacturers, has learned from experience that SKF Bearings are uniformly high in quality and dependability! Whatever your product, depend on SKF engineering to help you put the right bearing in the right place.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
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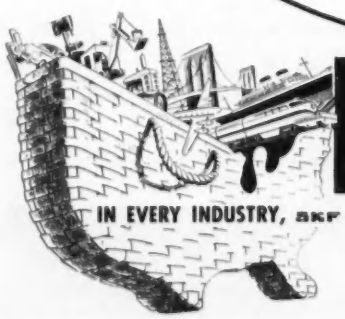
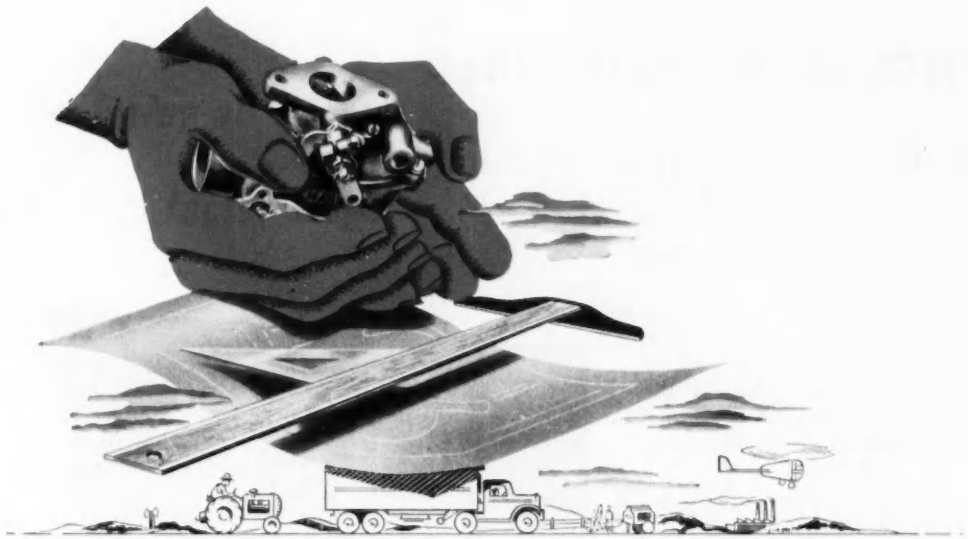


SKF®
BALL AND ROLLER BEARINGS

IN EVERY INDUSTRY, SKF Puts The Right Bearing In The Right Place



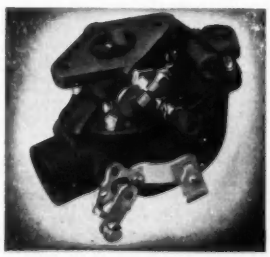
Look to field application engineering to increase your engine performance

For many years, in many diversified markets, Marvel-Schebler has concentrated on designing and adapting carbureters to meet individual requirements.

In order to satisfy all kinds of load demands, in all kinds of weather, Marvel-Schebler has relied on performance data supplied by field application engineering to help engine manufacturers obtain carbureters of proper design and calibration.

This has resulted in a constantly expanding wealth of experience in carbureters and carburetion for a wide range of applications. In the farm field alone, where rugged strength and unusual dependability provide that extra margin of economy in operation, 6 out of 10 farm tractors are using Marvel-Schebler carbureters as original equipment.

This experience can be of great help to you in the proper selection of standard equipment from the Marvel-Schebler line or in any of your carburetion problems. It is yours for the asking.



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B-W

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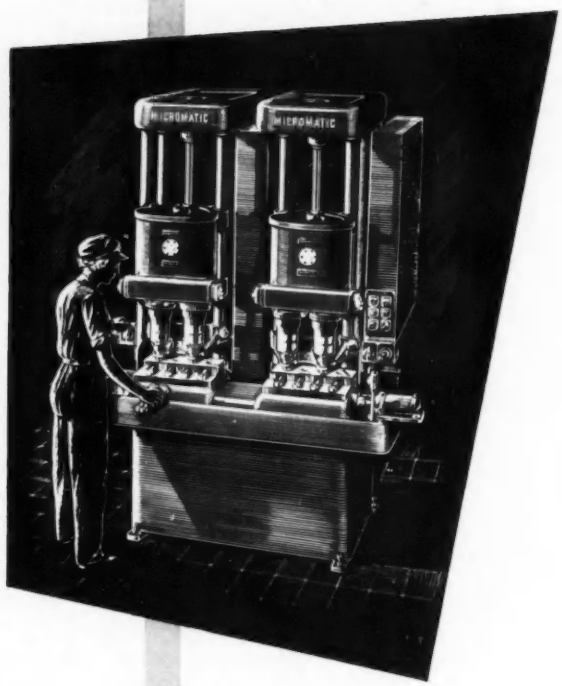

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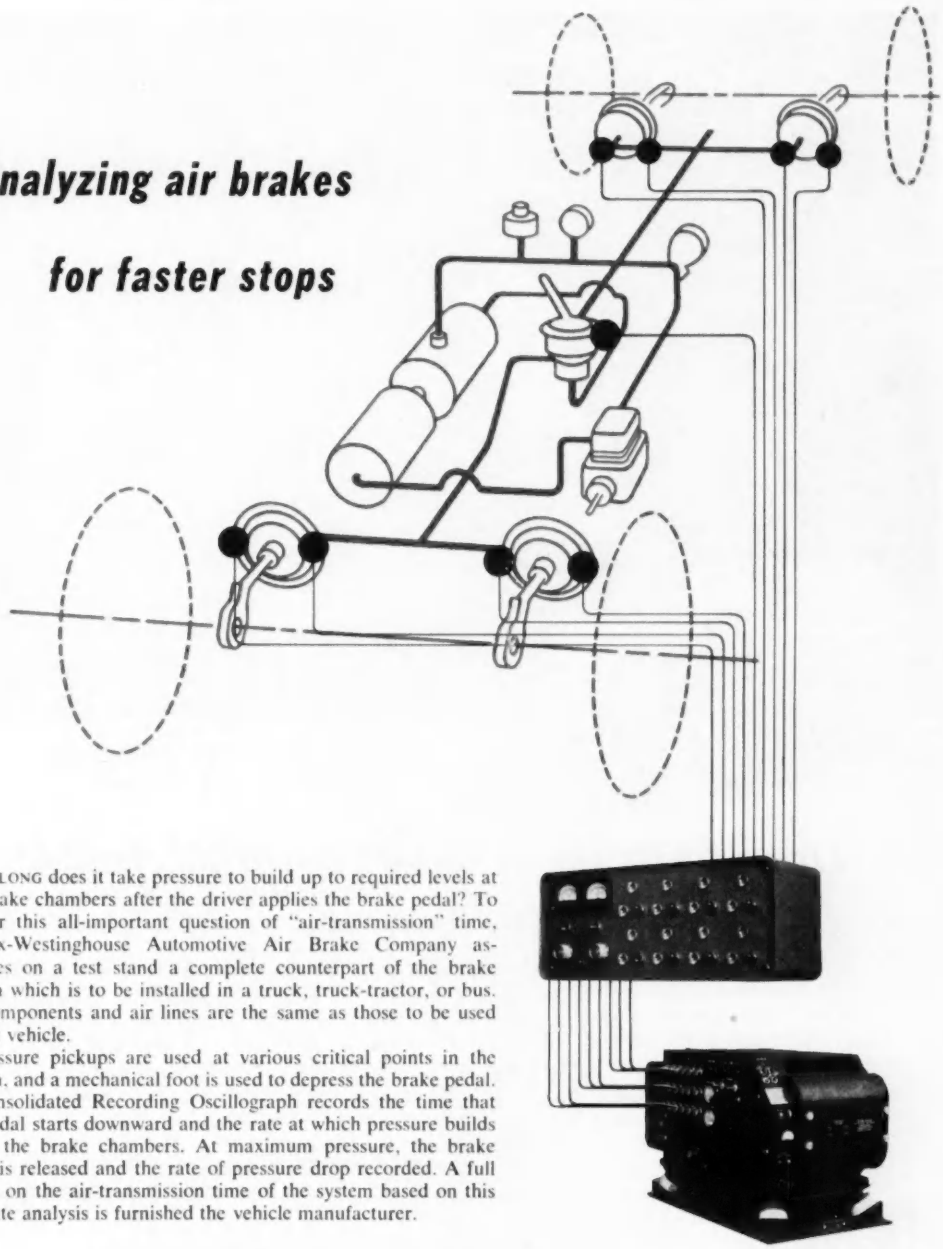
Analyzing air brakes for faster stops



HOW LONG does it take pressure to build up to required levels at the brake chambers after the driver applies the brake pedal? To answer this all-important question of "air-transmission" time, Bendix-Westinghouse Automotive Air Brake Company assembles on a test stand a complete counterpart of the brake system which is to be installed in a truck, truck-tractor, or bus. All components and air lines are the same as those to be used on the vehicle.

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*Now available on 1952 model Oldsmobiles, Buicks and Cadillacs

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Now Saginaw hydraulic power steering is available on passenger cars! And already it has won wide acceptance, for "there is no steering like power steering . . . and no power steering like Saginaw *hydraulic* power steering."

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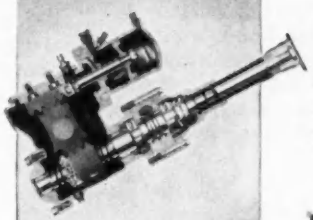
Saginaw's famous recirculating ball principle provides friction-free operation that is unique in the industry. It is a principle proved in over a million automotive steering gears.



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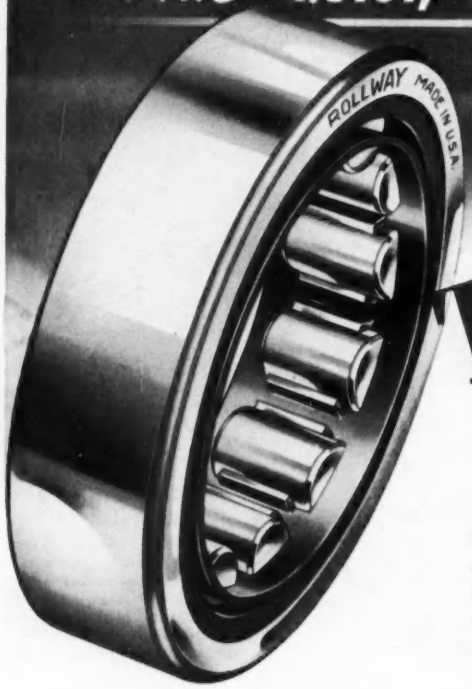
Positive Shaft Alignment *Plus* Quiet, Cool Running



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ROLLWAY'S Tru-Rol

steel cage bearings

Designed to approach the precise alignment, quietness and cool operation of a bronze-retainer bearing, the Rollway Tru-Rol—though not the equal of Rollway bronze-retainer types—does give the life expectancy and anti-friction properties required in many applications. Savings in cost are worth serious consideration.

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Broad lip flanges contoured to the curve of the rollers, assure true roller alignment, prevent skew and slide, greatly reducing friction losses and wear. They distribute the lubrication, maintaining the thin film essential for quiet, cool operation. Resulting axial alignment and dimensional stability of the rollers means positive shaft alignment over longer periods of service.

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Our engineering and metallurgical department will gladly work with your engineers in selecting the Rollway Bearing best suited to your needs. No cost, no obligation. Simply write or telephone your nearest Rollway sales office.

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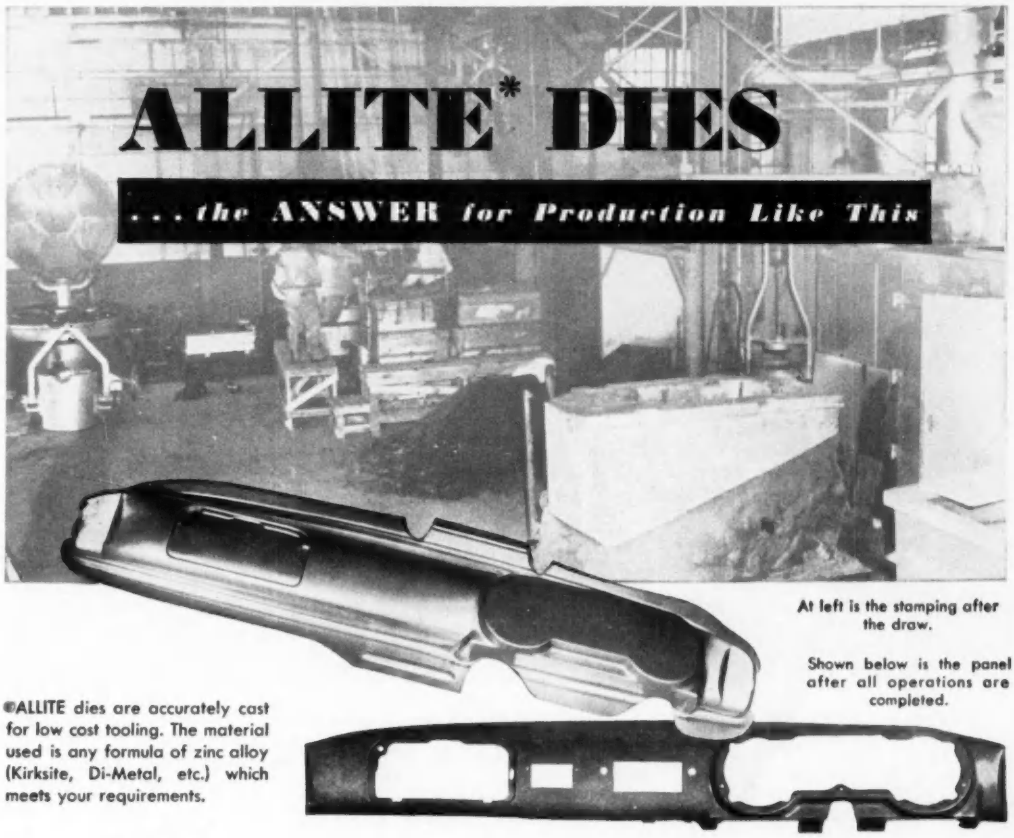

At left is the stamping after the draw.

Shown below is the panel after all operations are completed.

*ALLITE dies are accurately cast for low cost tooling. The material used is any formula of zinc alloy (Kirksite, Di-Metal, etc.) which meets your requirements.

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- The customer reports that more than 8000 stampings have been produced, with the original Allite draw die still in serviceable condition. This die is 100% zinc alloy.

This is typical of many Allite Die applications where all the advantages of low cost tooling, faster production starts and accurately built tools have been combined. And that has only been made possible by the close coordination of foundry and die shop facilities which only Allied can offer.

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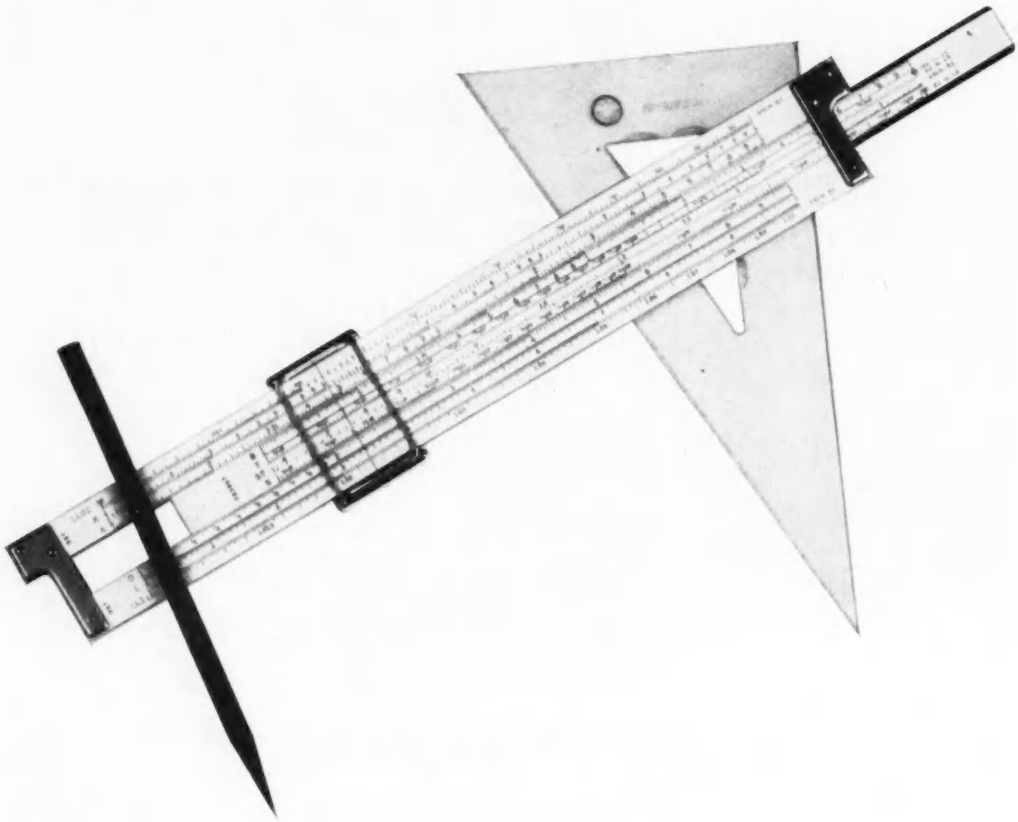
Hillsdale, Mich.



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Men from more than 120 top engineering schools are building rewarding careers at Boeing. So chances are, you'd be working with some of your classmates here. And you'd be a member of an Engineering Division that has earned world-wide renown for its trail-blazing contributions to both military and civil aviation.

If that's the kind of engineering prestige you'd like to enjoy, look into Boeing opportunities. This company has been growing steadily for 35 years. It provides the finest research facilities in the industry. It offers you work on such exciting projects as guided missiles and the fastest known bomber in the world: the B-47 six-jet medium bomber, as well as the still-classified B-52 eight-jet heavy bomber.

There are opportunities at Boeing for experienced and junior engineers in all fields, for aircraft

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also for servo-mechanism and electronics designers and analysts, and for physicists and mathematicians with advanced degrees.

You can work in Seattle, in the Pacific Northwest, or in Wichita, Kansas. Boeing provides a generous moving and travel allowance, gives you special training, and pays a good salary that grows with you.

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Write today to the address below, or use the convenient coupon.

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Dept. P-8
Boeing Airplane Company, Seattle 14, Wash.

Engineering opportunities at Boeing interest me. Please send me further information.

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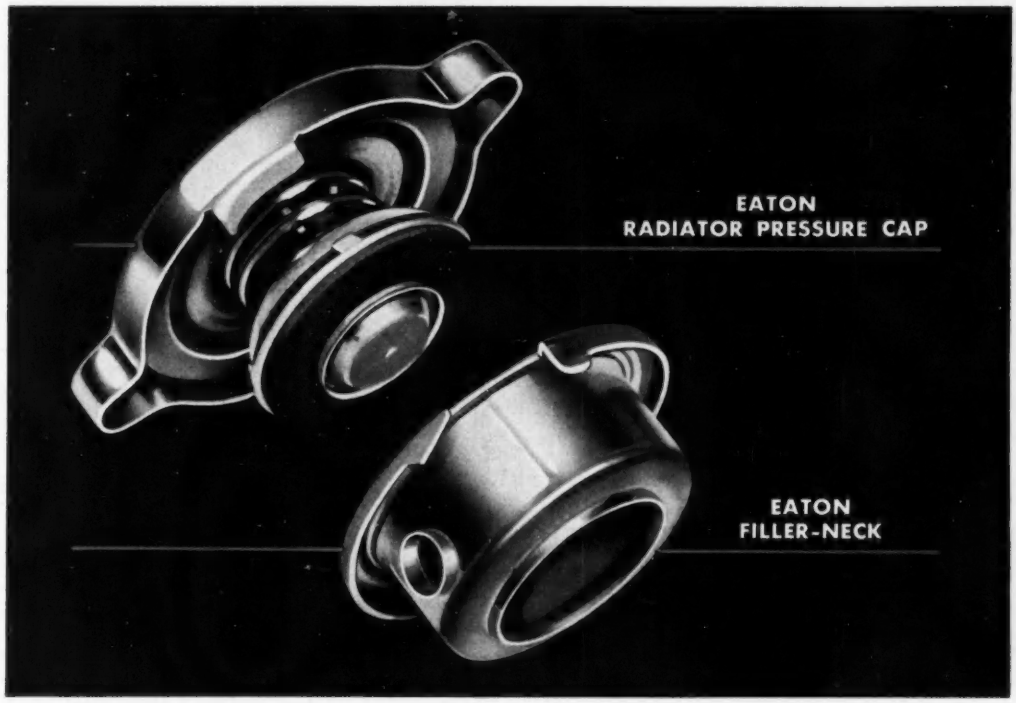

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By sealing the cooling system and raising the boiling point of the coolant, the Eaton pressure relief cap permits engines to operate in a more efficient and more economical temperature range without boiling away water or anti-freeze; provides for smoother engine performance, better lubrication, quicker warm-up, improved heater operation. In heavy-duty service, at high altitudes, or in extremely warm climates, this is an important safeguard against possible engine damage due to loss of coolant through evaporation. It also prevents loss of coolant due to surge. With a sealed cooling system vehicles can be designed with smaller radiators at considerable saving in cost.

Eaton offers the advantage of a single source of supply for pressure cap and filler-neck requirements; eliminates divided responsibility; assures positive mating of cap and neck; saves engineering and purchasing contact time. Eaton engineers will welcome an opportunity to work with you in developing the most efficient and economical closure—standard or pressure type—for your cooling systems.

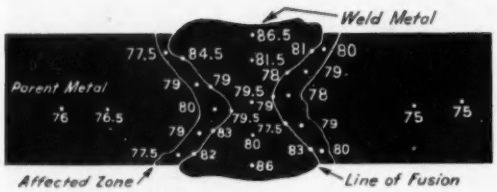
EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

STAMPING DIVISION: Detroit Office, 18001 James Couzens Highway, Detroit 35, Michigan

ORIGINATORS OF THE BAYONET-TYPE CAP AND FILLER-NECK FOR PRESSURIZED COOLING SYSTEMS

This Low-Alloy High-Strength Steel Welds as Readily as Carbon Grades



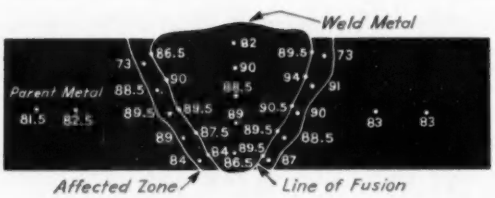
Rockwell B hardness on ½-in. manual arc-welded plate of Mayari R, stress-relieved at 1050 deg F.

Mayari R is a low-alloy, high-strength steel that can be welded by the ordinary methods used for plain carbon steel . . . electric-resistance, including spot-, seam-, and flash-butt . . . electric-arc, including metallic, carbon, and inert-arc . . . automatic-submerged-arc . . . and gas-welding processes.

There is no difference in the equipment, the technique, or the welding speed with Mayari R.

A non-air-hardening grade, Mayari R shows no appreciable hardening from welding temperatures. Results of tests made on welded Mayari R indicate that the welds are equally as strong as the parent metal.

Full information on welding and fabricating this steel is readily available for your files. Write or phone any Bethlehem sales office and ask for a copy of Mayari R Catalog 259.



Rockwell B hardness on ¼-in. manual arc-welded Mayari R plate, as welded.

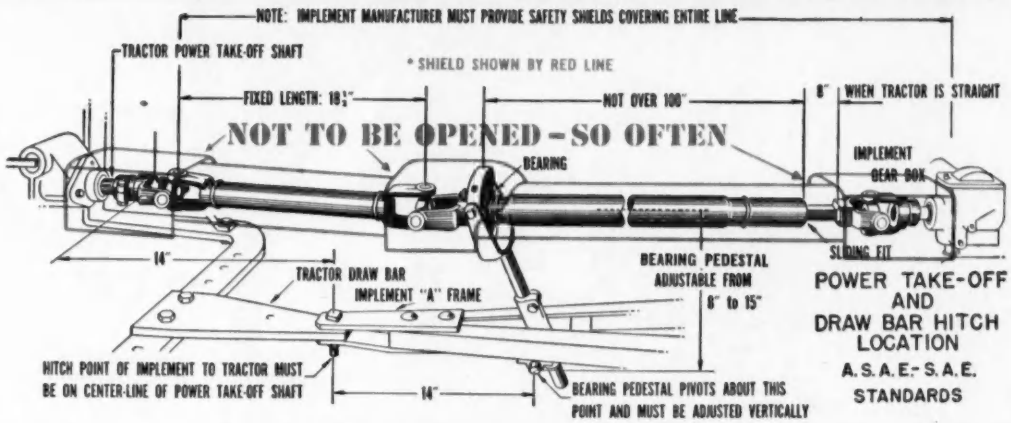
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

Mayari R *makes it lighter... stronger... longer lasting*

Keep Your SAFETY SHIELDS In Place — with Once-a-Season Lubricated MECHANICS UNIVERSAL JOINTS


NOTE: IMPLEMENT MANUFACTURER MUST PROVIDE SAFETY SHIELDS COVERING ENTIRE LINE
TRACTOR POWER TAKE-OFF SHAFT
* SHIELD SHOWN BY RED LINE
FIXED LENGTH: 18½"
NOT OVER 100"
8" WHEN TRACTOR IS STRAIGHT
NOT TO BE OPENED – SO OFTEN
BEARING
IMPLEMENT GEAR BOX
SLIDING FIT
14"
TRACTOR DRAW BAR
IMPLEMENT "A" FRAME
BEARING PEDESTAL ADJUSTABLE FROM 8" to 15"
HITCH POINT OF IMPLEMENT TO TRACTOR MUST BE ON CENTER-LINE OF POWER TAKE-OFF SHAFT
14"
BEARING PEDESTAL PIVOTS ABOUT THIS POINT AND MUST BE ADJUSTED VERTICALLY
POWER TAKE-OFF AND DRAW BAR HITCH LOCATION
A.S.A.E.-S.A.E. STANDARDS

SIZE	TYPICAL APPLICATIONS	RATED H.P. AT 538 R.P.M.
1½ RA	1 - 2 Row Corn Picker — Binders — Small Combines	10 H. P.
2 RA	2 Row Corn Picker — Binders — Large Combines — Windrows	20 H. P.
3 RA	Large Balers — Ensilage Harvesters — Roto Beaters — Etc.	30 H. P.

All drive lines can be supplied with safety slip clutches which can be set for any torque needed.

Operators resent having to stop several times a day to remove safety shields, grease plain bearing joints and replace the shields — or risk breakdowns. Don't let them blame YOUR machine. Specify MECHANICS Roller Bearing UNIVERSAL JOINTS that require, at most, only once-a-season lubrication. The operator will leave the shields on — and won't blame YOUR MACHINE for "joint trouble" — because MECHANICS joints do not waste his time.

MECHANICS UNIVERSAL JOINT DIVISION

Borg-Warner • 2022 Harrison Avenue, Rockford, Illinois

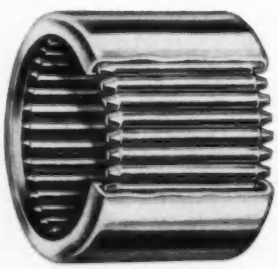
MECHANICS *Roller Bearing* BW UNIVERSAL JOINTS

For Trucks • Tractors and Farm Machines

for long, dependable service...

Torrington Needle Bearings have set outstanding service records in countless applications throughout industry. The reason is simple. Needle Bearings are made to last. The one-piece shell which serves as the outer raceway is accurately drawn from carefully selected strip steel. After forming, it is carburized and hardened, with no further grinding that might destroy the wear-resistant raceway surfaces. The precision-ground rollers are thru-hardened for long life.

Because of this careful selection of materials and precision workmanship to close tolerances, Torrington Needle Bearings provide accurate, dependable performance in the most rugged applications. Ask our engineering department to help you determine how you can use Needle Bearings to advantage in *your* product.



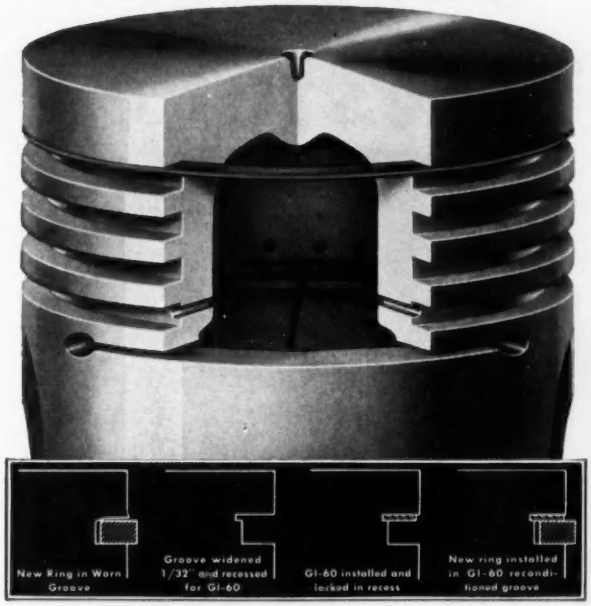
THE TORRINGTON COMPANY
Torrington, Conn. South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Straight Roller • Ball • Needle Rollers

Sealed Power Pioneered

the only dependable, economical answer to top-ring groove wear


New Ring in Worn Groove
Groove widened 1/32" and recessed for GI-60
GI-60 installed and locked in recess
New ring installed in GI-60 reconditioned groove

Sealed Power GI-60 Groove Insert

STILL ALONE IN ITS FIELD

Top-ring groove wear is a problem as old as piston rings. Top-ring grooves have always had the least lubrication, the most heat, the heaviest wear. Many remedies were tried. Regrooving and installing wider rings violated the intent of the engine designer. A loose, floating spacer amounted to the same thing as using a wider ring in two sections.

Sealed Power engineers wrestled with the problem for years, and came up with the only satisfactory answer to date. It is a heat-treated, spring-steel insert, securely anchored to the top of the ring groove, which has been regrooved to an absolutely true surface 1/32" wider than before. A recess 1/32" wide is cut at the top, and the insert locks itself permanently into this recess, held by its own inward tension, and dished to hug the top of the groove. It is called the Sealed Power GI-60 Groove Insert.

Many fleet owners are now using Sealed Power GI-60 on new replacement pistons, as well as re-conditioned pistons. One reports that pistons in his fleet formerly averaged less than 50,000 miles. Since adopting the standard practice of installing GI-60, average life has increased to more than 200,000 miles.

Sealed Power GI-60 Groove Insert is only one of many improvements originated by Sealed Power, leader in the field since 1911.

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN

Sealed Power Piston Rings

PISTONS • CYLINDER SLEEVES

New Type of Tire Protects Against All Kinds of Tire Failures

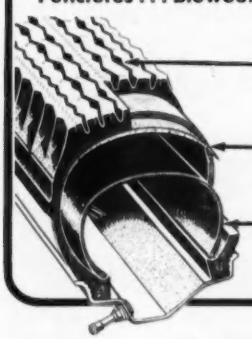
Firestone Supreme

The World's First And Only Blowout-Safe, Puncture-Sealing, Tubeless Tire

HERE at last is a tire that provides the utmost in protection against the dangers of blowouts, punctures and skidding. This revolutionary new tubeless tire gives you longer mileage, ease of steering and riding comfort beyond anything you have ever known.

For full details and specifications write The Firestone Tire & Rubber Company, Akron, Ohio.

Here's Why It Protects You Against ALL THREE DANGERS . . . Punctures . . . Blowouts . . . Skidding



Patented, Non-Skid Tread with New Traction Boosters and Skid-Resistors

Puncture-Sealing, Soft Rubber Inner Layer Seals Punctures Instantly

Safety Diaphragm . . . an Emergency Tire . . . Holds Air in Case of Blowout

Now, For The First Time . . . . EVERY SAFETY FEATURE IN ONE TIRE

PUNCTURE-SEALING

Gives Complete Protection Against Punctures and Roadside Delays

BLOWOUT-SAFE

Gives Complete Protection Against Danger of Blowouts

SKID-SAFE

Greater Non-Skid Safety Under All Weather Conditions

Enjoy the Voice of Firestone on radio or television every Monday evening over NBC

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Koppers expands service on American Hammered

Industrial and Aircraft Piston Rings

Because of the sale of its automotive replacement piston ring business Koppers now is in a position to further increase its leadership in piston and sealing rings for aircraft, general industrial, marine, commercial engine, railroad and oil field applications.

To present and prospective users of Koppers American Hammered Industrial Rings, this means increased engineering service, through concentrated attention to the solution of industrial and aviation ring problems; and greater production capacity for both original equipment and replacement rings. Our available manufacturing facilities include:

A large foundry equipped for both static and centrifugal casting . . . a modern heat-treating plant . . . one of the largest and most up-to-date chromium plating plants . . . modern machine shops . . . an efficient engine test laboratory . . . a modern and complete piston ring research laboratory.

In industrial and aviation rings, American Hammered *means* Koppers . . . builders of *engineered* products for industry.

Write, wire or phone us for the right answer to your piston or sealing ring problems, today. Koppers Company, Inc., *Piston Ring Department*, 1528 Hamburg Street, Baltimore 3, Maryland.

KOPPERS

Koppers American Hammered Industrial Piston Rings

Only* KOPPERS *can furnish K-Spun® and Porous Chrome!

2nd. edition

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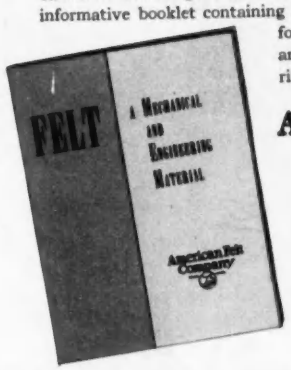

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The W&T Precision Dial Manometer answers the problem of conveniently measuring pressure with a sensitivity of 1 part in 10,000.

This sturdy, compact instrument, which is widely used for wind tunnel work, power plant test stands and in gas turbine testing, has a large easy-to-read dial. It is custom calibrated in **any** pressure units over various ranges up to a maximum of 200 inches of mercury.

In addition, the W&T Precision Dial Manometer possesses these outstanding advantages:

Accuracy .....1 part in 1000
Scale length ..45"
Case .....pressure tight, metal for flush mounting.
Full protection against over pressure.
Measures gauge pressure, vacuum and differential pressure.

This instrument with its sensitive response and precision results is typical of a wide variety of pressure instruments of all types — from low pressure indicators to altimeters — manufactured by W&T. If you have a problem in pressure measurement, write, telling us the details. We'll be glad to help.

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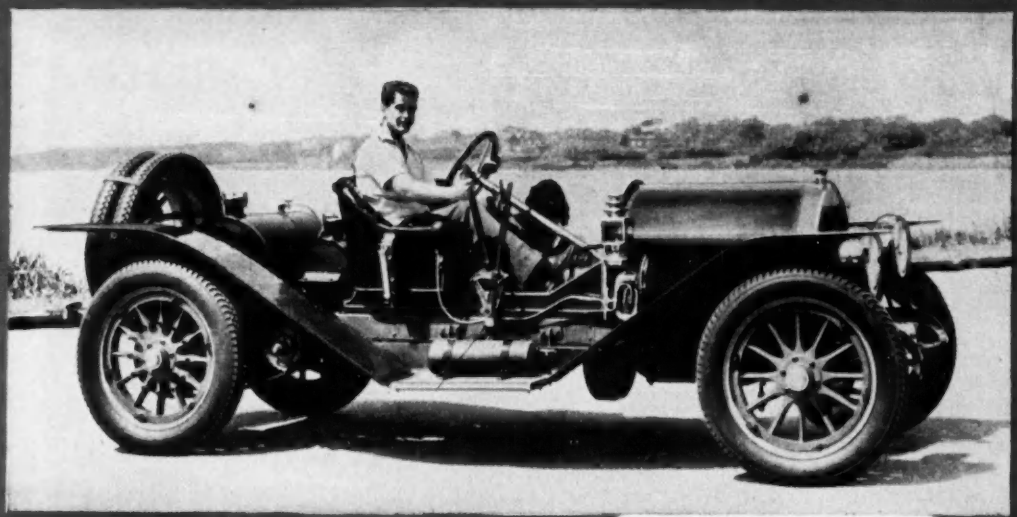

From the Collection Archives

In the automotive industry

Send for free print

Four-cylinder, 53-hp. Simplex automobile, 1910. This luxurious car sold for $5,400, featured 129" wheelbase, double-chain final drive, Krupp steel channel frame, four-passenger capacity, a weight of 4500 pounds.

This is one of a series of old automobile prints that will appear in future Morse advertisements. Write for free, enlarged copy, suitable for framing for your collection.

M=TC

Morse *means* Timing Chains

From the time of the Simplex chain-drive automobile shown above, Morse has produced over 54 million timing-chain drives for the automotive industry.

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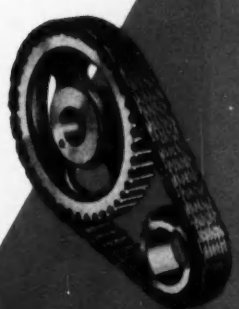
Talk with Morse engineers. In short order you'll see why M = TC; Morse *means* Timing Chains.



MORSE
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POWER TRANSMISSION
PRODUCTS

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MORSE CHAIN COMPANY
Dept. 375, 7601 Conrad Avenue
DETROIT 10, MICHIGAN

4 Way Shock Protection

NO. 1753 MOHAWK CONTOUR

Genuine LEATHER

New MILSCO "Mohawk"

Engineered for Comfort — Streamlined for Sales Appeal

Milsco proudly presents the new "Mohawk" . . . padded with thick foam rubber, covered with high grade black flexible leather, the new Milsco "Mohawk" gives you extra comfort, extra safety. Extra heavy steel base.

Left to right .....22"
Front to rear .....21½"

Milsco MILWAUKEE

MILSCO MFG. CO.
2758 N. Thirty-third St.
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A Yes—SEE ALCOA. Alcoa's finishing laboratories are continually improving and developing finishes for aluminum—painted, electroplated, anodized plus chemical and mechanical treatments. For the latest information, simply write on your company letterhead to:

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Aluminum Shell Lamp Holder and Screw Shell manufactured and finished by Leviton Manufacturing Co.

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Replies to Box No. 116, SAE Journal
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Brinell—Shore—Scale

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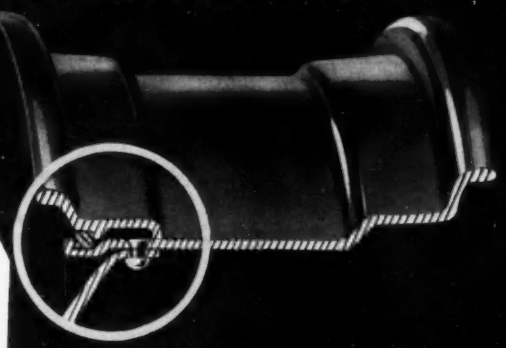
KELSEY-HAYES

Advanced Design

3 pc. Truck Wheel



With the EXCLUSIVE K-H Safe LOCKING DEVICE

Hailed by truck manufacturers and tire servicing men as the safest ever devised! As tire is inflated the retaining ring locks the assembly even tighter. Also assures greatest convenience in tire mounting, demounting, and tube insertion!

Available in all popular sizes for leading makes of trucks . . . to increase tire mileage 30% to 50%!

BUILT TO THE STANDARDS OF THE FINEST PRODUCTS OF

KELSEY-HAYES WHEEL COMPANY

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PRODUCTS: Wheels—Hub and Drum Assemblies—Brakes—Vacuum Brake Power Units—for Passenger Cars, Trucks, Buses—Electric Brakes for House Trailers and Light Commercial Trailers—Wheels, Hubs, Axles, Parts for Farm Implements.

PLANTS: Kelsey-Hayes Plants in Michigan (4); McKeesport, Pa.; Los Angeles, Calif.; Davenport, Iowa; Windsor, Ontario, Canada.

On every count, your greatest

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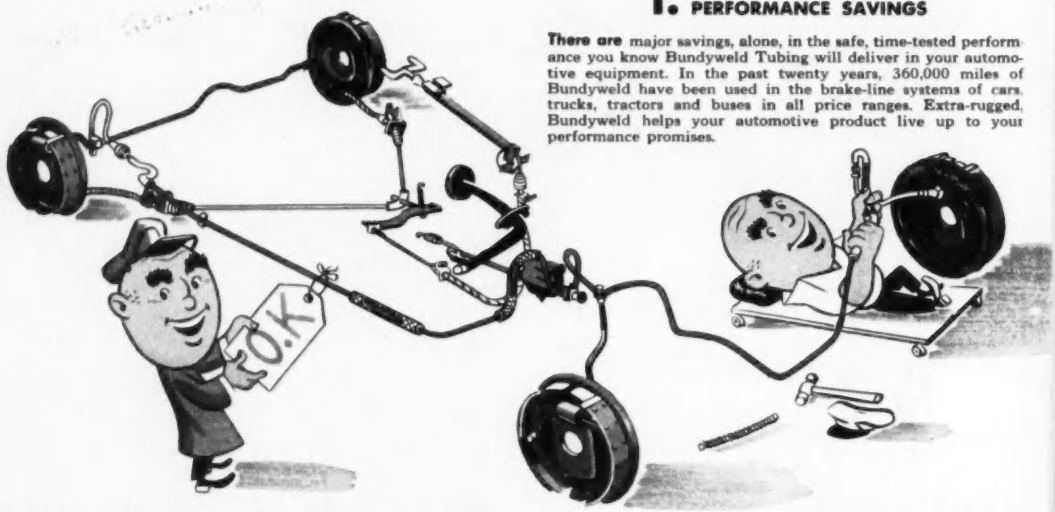
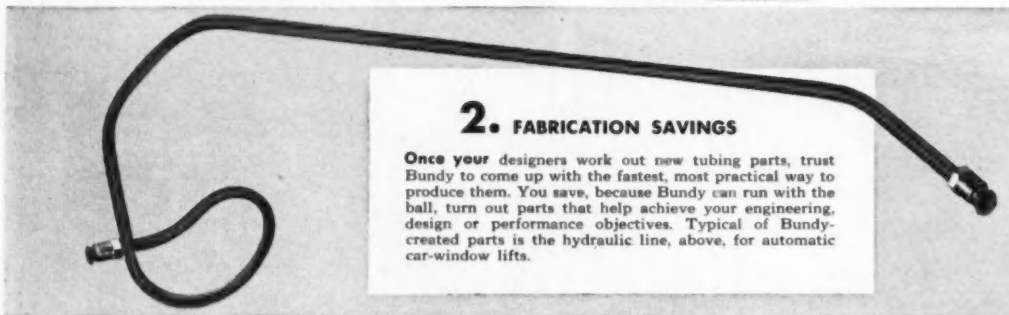
There are major savings, alone, in the safe, time-tested performance you know Bundyweld Tubing will deliver in your automotive equipment. In the past twenty years, 360,000 miles of Bundyweld have been used in the brake-line systems of cars, trucks, tractors and buses in all price ranges. Extra-rugged, Bundyweld helps your automotive product live up to your performance promises.





2. FABRICATION SAVINGS

Once your designers work out new tubing parts, trust Bundy to come up with the fastest, most practical way to produce them. You save, because Bundy can run with the ball, turn out parts that help achieve your engineering, design or performance objectives. Typical of Bundy-created parts is the hydraulic line, above, for automatic car-window lifts.

Bundyweld® Tubing

DOUBLE-WALLED FROM A SINGLE STRIP

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Presto . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive patented Bundyweld beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

Bundy Tubing Distributors and Representatives: Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • **Chattanooga 2, Tenn.:** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • **Chicago 32, Ill.:** Lapham-Hickey Co., 3333 W. 47th Place • **Elizabeth, New Jersey:** A. B. Murray Co., Inc., Post Office Box 476 • **Philadelphia 3, Penn.:** Ruttan & Co., 1717 Samson St. • **San Francisco 10, Calif.:** Pacific Metals Co., Ltd., 3100 19th St. • **Seattle 4, Wash.:** Eagle Metals Co., 4755 First Ave. South **Toronto 5, Ontario, Canada:** Alloy Metal Sales, Ltd., 181 Fleet St., East • **Bundyweld nickel and Monel tubing is sold by distributors of nickel and nickel alloys in principal cities.**

automotive tubing buy

Specify Bundyweld Tubing and you buy time-proved, safe performance, priceless in itself. You buy tubing features without parallel, backed by engineering skills *dedicated* to cutting costs.

Measure all that you buy in Bundyweld Tubing against the performance standards and cost requirements you set for brake lines, oil lines, and other automotive tubing parts.

You buy safety. Since 1930, over a third of a million miles of Bundyweld Tubing have been used in brake lines of cars, trucks, buses, and tractors of all prices, kinds, and types. Billions of miles traveled by these vehicles prove Bundyweld's safety.

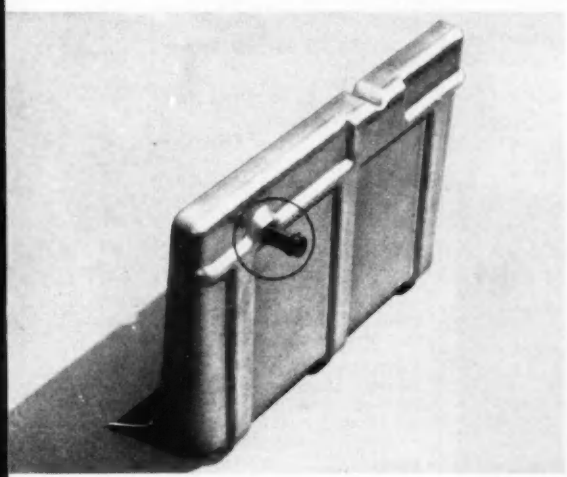
You buy tubing features without parallel. Bundyweld is the only tubing double-walled from a single strip, copper-brazed through 360° of wall contact. It's extra-sturdy, extra-strong; has high bursting strength, high resistance to severe shock and vibration fatigue.

You buy the industry's finest engineering skills, which can mean major savings in the long run. Bundy men called in during critical design and planning phase are often able to bring about major savings in materials, tooling costs, or production time at that point.

Then, promptly, and *as specified*, Bundyweld rolls into your production lines—either fabricated by Bundy or in lightweight coils and lengths for easy, economical fabrication by your men.

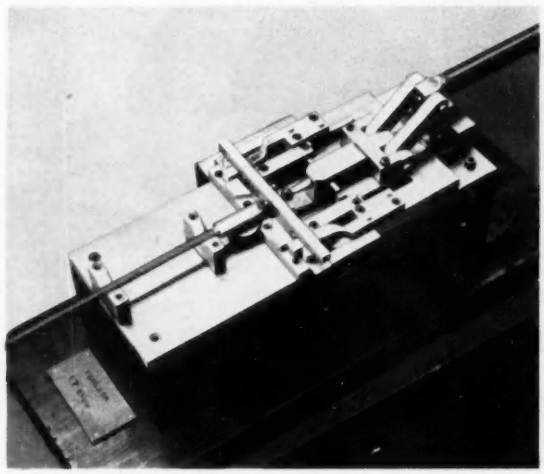
Price-minded, performance-minded automotive engineers know there is no adequate substitute for Bundyweld Tubing. *Or* for Bundy skills.

Contact a Bundyweld Distributor (listed lower left), or write direct to *Bundy Tubing Company, Detroit 14, Michigan*



3. COSTS CUT

You save through constant efforts inside Bundy to ferret out better, faster, more economical production methods. Example: Special burring operation on drain tube (circled) in battery tray, above, has now been eliminated by an improved production technique, and savings passed on to Bundy customer in lowered costs per unit. For *true* economy in automotive tubing parts, specify Bundyweld!



4. MORE PRODUCTION SAVINGS

Bundy-built assembler, above, demonstrates more typical Bundy production advances. Assembler automatically slips rubber washer over bead at end of tube, eliminates former expensive hand operation, speeds output at appreciably lower cost, which Bundy customer shares. Look into the ultimate cost of tubing; count by count, you'll find Bundyweld is your finest tubing "buy."

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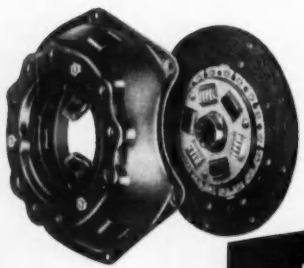

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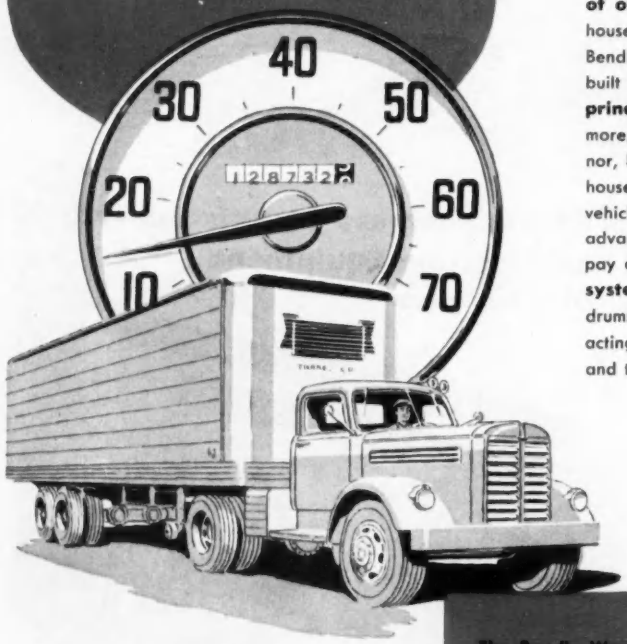

Every truck and bus prospect is on the lookout for features that guarantee long years of **rugged, reliable performance.** And, that's especially true when it comes to brakes. It's the reason **thousands of owners and drivers** specify Bendix-Westinghouse Air Brakes. They know, for example, that the Bendix-Westinghouse Compressor is designed and built on the same **proven reciprocating piston principle** as the engines in your vehicles. What's more, this husky unit, like the brake valves, governor, brake chambers and all other Bendix-Westinghouse components, often is still in use after the vehicle itself has been retired from service. So take advantage of this **remarkable record**—make it pay off for your customers. Give them a **lifetime system** and more braking mileage on linings, drums, and tires, by specifying dependable smooth-acting Bendix-Westinghouse—the world's most tried and trusted air brakes!

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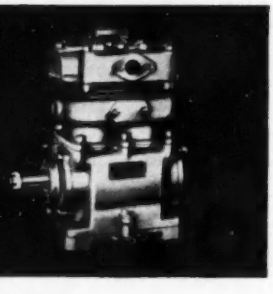
The Bendix-Westinghouse Compressor—heart of the air brake system—performance proven over more miles on more installations than any other compressor available!



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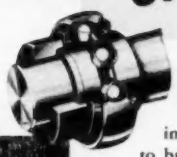
The Oliver Model 33 Self-Propelled Combine with 12' or 14' header ... Fafnir equipped



Fafnir Wide Inner Ring Ball Bearing Self-Locking Collar easiest of all to install.

The Oliver No. 5 Single Row Corn Picker-Husker

The Oliver No. 4 Tractor Mounted Corn-Picker-Husker.

In building farm machinery, The Oliver Corporation uses Fafnir Ball Bearings at many important turning points, not only to bring out the full advantages of design features but to assure "on Schedule" performance.

The Model 33 self-propelled combine is equipped with eight Fafnir Wide Inner Ring Ball Bearings with Self-Locking Collars plus nine Radial Ball Bearings. Those on the fan shaft, rear beater shaft, cylinder shaft and idler pulley straw elevator drive, have Fafnir Mechani-Seals that positively keep lubricant in — contaminants out. Models 4 and 5 corn pickers feature the famous Fafnir Flangettes.

More and more farm machinery is being equipped with Fafnir Ball Bearings because of their wide selection of types and sizes, uniformly high quality, easy installation, plus ... the Fafnir "attitude and aptitude", a way of looking at bearing problems from the designer's viewpoint — an aptitude for supplying the right bearing to fit the need, gained from over 40 years of experience in the manufacture of ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

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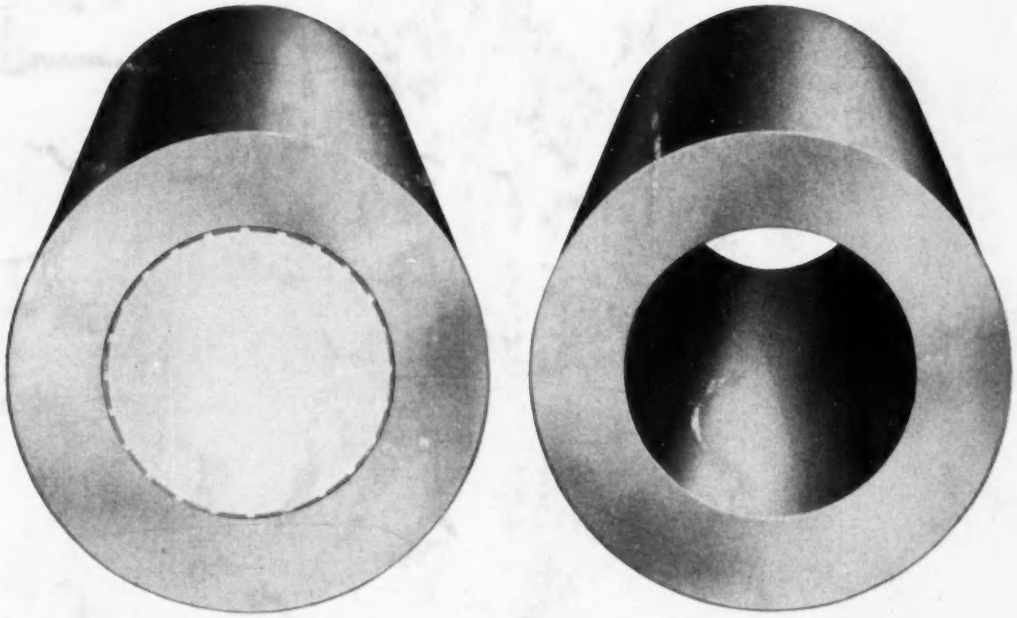

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You make your machine tools more productive by using Timken seamless tubing. Since you don't have to drill the center hole, screw machine stations can be released for other operations. You get added machining capacity without adding machines.

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